VANCOUVER

AND

DISTRICTS

JOINT SEWERAGE

AND

DRAINAGE BOARD

VANCOUVER, B. C.
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THE BURRARD PENINSULA JOINT SEWERAGE SYSTEM
MEMBERS OF THE JOINT COMMITTEE

1911.

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1912

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Vancouver and Districts Joint Sewerage & Drainage Board

LETTER OF TRANSMITTAL

820 New Birks Building,
Montreal.

To the Chairman and Members,
Burrard Peninsula Joint Sewerage Committee.

GENTLEMEN:—

I have the honour to submit herewith my final report on the Burrard Peninsula Joint Sewerage Scheme.

I was engaged by this Committee in June, 1911, to investigate and report on a suitable scheme. Early the following July, I visited the City to familiarize myself with local conditions and advise in preliminary moneys and the collection of data.

This work was carried on under the supervision of the City Engineer previous to the appointment in January, 1912, of a Resident Engineer, who took charge of the work and reported to me direct.

Preliminary reports were submitted on January 4th and May 31st, 1912, and two interim reports embodying the main features of the one now submitted, were presented to the Committee on December 12, 1912, and January 31, 1913.

May I, in transmitting this report, remark on the wisdom and foresight shown by those who took the initiative in promoting this scheme.

The participating Municipalities are to be congratulated upon being, I believe, the first to voluntarily attempt united action in an undertaking of such magnitude in advance of pressing necessity.

I wish further to acknowledge the hearty co-operation of the Members of the Joint Committee, and the Municipal officials, who have always shown a live interest in and an appreciation of the importance of the problems under investigation. I feel the Committee were fortunate in securing a Resident Engineer fittingly qualified for the position by his previous training and experience on the staff of an engineering firm of international reputation.

Respectfully,

(Signed) R. S. LEA.

820 New Birks Building,
Montreal, Que., Feb. 1st, 1913.

To the Chairman and Members,
Burrard Peninsula Joint Sewerage Committee.

GENTLEMEN,—

Before proceeding to a detail discussion of the various headings under which this report is written, it will, I think, be well to put before you a brief summary of the subject matter.

1. The area of the Peninsula, including New Westminster, is 55,600 acres.
1. The annual rainfall, averaged over the last seven years, is 56 inches, and the average number of wet days 174.
3. The present population (1912) is estimated at 182,000. The estimated population, 1950, is 1,400,000.
4. At the present time about 6,000 acres is more or less efficiently sewered. There is no standard basis for design or construction.
5. The investigations by the State Board of Health, New York, and the British Royal Commission, have thrown much light on the disposal of sewage in tidal waters.
6. The most suitable points of outfall are: (a) into English Bay on the line of Imperial Street; (b) into Burrard Inlet at Clark Drive and other points; (c) into Fraser River. The interception of floating matter is essential in (a) and desirable in (b). There is a possibility of some form of treatment being required in the future at (c).

It is essential that the English Bay foreshore should be preserved from pollution. The principle of the separate system is advocated on the areas draining to English Bay and False Creek. Burnaby Lake is incapable of digesting sewage, and the separate system is advocated on that area.

7. It is proposed to construct:
   (a) An interceptor along the South shore of English Bay from Imperial Street to Bridge Street, with the necessary outfall works and trunks.
   (b) An interceptor along Clark Drive from Seventh Avenue to the Inlet, with the necessary outfall works and trunks.
   (c) An interceptor South of Still Creek and Burnaby Lake, discharging to the Fraser.
   (d) Various trunks on the South slope of the Peninsula, discharging to the North Arm.

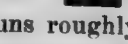
(e) A West End interceptor and outfall, discharging beyond Brockton Point, and a trunk and outfall in Hastings Townsite.

(f) Improvement works, Brunette River and Still Creek.

8. The estimated cost of construction during the next five years is 5 1-2 million and covers the above works. The estimated additional cost of completing the scheme to cover the whole Peninsula is 5 1-2 million during the following 25 years.

9. A Joint Sewerage Board should control and carry out the work. If the Government guarantee the bond issue it should consist of one representative appointed by the Government and one by each of the Municipalities interested.

Topographical

Plan No. 1 shows the natural features and Municipal Boundaries of the two Peninsulas. They are split up into defined drainage areas by three main ridges—two running from East to West and one from North to South, the height of land taking the form of a letter H on its side, thus: 

The first ridge runs roughly parallel to the shore of the Inlet from one-quarter (¼) to two (2) miles inland, from Port Moody to Stanley Park.

The second ridge runs parallel to the first and also to the Fraser River from the junction of the Brunette and Fraser Rivers to the extreme end of Point Grey.

The third ridge, forming the cross-bar of the H, runs in a Southerly direction from Hastings Park.

I have named the five natural drainage areas formed by these ridges by their places of discharge, and their respective acreages are set out hereunder, together with the areas in each Municipality.

Acreage of Natural Drainage Areas.

	Vancouver.	South Vancouver.	Burnaby.	Point Grey.	Total
Burrard Inlet	2,200	.....	2,600	.....	4,800
False Creek	3,600	2,900	.....	900	7,400
English Bay	1,750	.....	.....	4,200	5,950
Fraser River	.....	4,800	5,500	7,300	17,600
Burnaby Lake	1,700	1,200	14,100	.....	17,000
	9,250	8,900	22,200	12,400	52,750

Burrard Inlet Drainage Area.

This area comprises a strip of land along the South shore of Burrard Inlet; the distance inland of the divide varying from one-quarter of a mile to two miles, and the height of land ranging from ten feet above sea level, at the narrow neck between False Creek and the Inlet, to some twelve hundred feet in the neighbourhood of Barnet.

False Creek Drainage Area.

The limits of this area extend from one-quarter mile back from the creek on the North, to three and a half (3½) miles on the South-east. As a general rule the contours run parallel to the shore line of the Creek, and, with the exception of some few flat places, the slope is good. The natural drainage is by numerous small creeks.

English Bay Drainage Area.

This area lies to the South of English Bay and to the West of the False Creek area. The Easterly half of this area is high with a steep fall to the water. The natural drainage of the Westerly half of this area is through a flat valley running in a South-easterly direction to the Bay. There is a small low level area near Kitsilano Beach.

Fraser River Drainage Area.

This area includes the whole of the Southern portion of the Peninsula. Starting from the Brunette River on the East, the ridge runs rapidly to an elevation of four hundred feet above high water, continuing almost due West at an elevation varying between three and four hundred feet to Point Grey, where the ground falls abruptly to sea level. Generally speaking, the contours run parallel to the river and the ridge, although their regularity is somewhat broken by deep ravines and creeks, especially in South Vancouver. There are two low lying tracts, one lying within the bend of the river in the South of Burnaby, and the other in Point Grey in the Indian Reserve. Towards Point Grey the ground rises almost precipitously from the river flats.

Burnaby Lake Drainage Area.

This area comes next to the Fraser River area in size, and from a drainage point of view presents the most difficulties. In shape it resembles a large dish. Its boundaries vary in elevation from some 1200 feet above sea level, near Barnet on the North to just over a hundred near Trout Lake. The Northern slope rises gradually to

the ridge. This has not been contoured. It is mostly uncleared. The height of the divide from the Inlet area varies from 300 feet to the 1200 feet elevation near Barnet. The Southern slope is more broken than the Northern, and there are several small drainage areas. The Westerly portion of the area is drained by a long flat creek, known as Still Creek, which divides into two branches near the Municipal Boundary and discharges into Burnaby Lake, to which most of the Easterly portion drains. The outlet from the Lake is by the Brunette River, which discharges into the Fraser just above New Westminster.

Meteorological.

The annual rainfall and number of wet days for the past seven years are set out hereunder. The records have been supplied by Mr. Shearman, the Government Meteorologist. The rain gauge is located at 2273 Sixth Avenue.

Summary of Wet and Dry Days from January, 1906, to December, 1912.

Month	1906 Wet	1906 Dry	1907 Wet	1907 Dry	1908 Wet	1908 Dry	1909 Wet	1909 Dry	1910 Wet	1910 Dry	1911 Wet	1911 Dry	1912 Wet	1912 Dry
January	22	9	13	18	23	8	21	10	22	9	25	6	22	9
February	15	13	15	13	20	9	24	4	16	12	16	12	17	12
March	11	20	18	13	18	13	14	17	18	13	11	20	5	26
April	13	17	11	19	14	16	11	19	15	15	8	22	13	17
May	15	16	7	24	15	16	17	14	10	21	13	18	11	20
June	17	13	10	20	7	23	7	23	11	19	6	24	9	21
July	2	29	4	27	6	25	15	16	3	28	5	26	10	21
August	4	27	11	20	7	24	7	24	8	23	7	24	11	20
Sept.	14	16	10	20	11	19	11	19	9	21	15	15	8	22
October	22	9	14	17	19	12	18	13	18	13	12	19	20	11
Novem.	19	11	23	7	20	10	23	7	23	7	23	7	23	7
Decem.	24	7	20	11	20	11	17	14	25	6	27	4	26	5
Totals	178	187	156	209	180	186	185	180	178	187	168	197	175	191
Total Rainfall	58.55		57.59		62.69		58.53		58.36		52.26			

NOTE.—When rainfall is 0.01 inch or over, the day is considered to be wet.

It is interesting to note that although Vancouver has an annual rainfall of more than twice that of London, England, Vancouver has fewer wet days in the year. The actual figures for London, England, are:—

	Total Rainfall.	Wet Days	Dry Days
1909	26.75	190	175
1910	25.08	186	179

The gauges are old-fashioned, readings being taken only twice a day, consequently there is no record of the short rain storms of high intensity of the thunder storm type, the chief controlling factor in sewer design. Fortunately, this type rarely occurs. The meteorological peculiarity of the district is a continuous rate of moderate intensity—a peculiarity common to other parts of the Pacific Coast.

Very complete records have been kept in the past at San Francisco and Seattle, and I am indebted to the City Engineer of New Westminster for the records of the automatic gauge established there at the end of 1911.

From the foregoing data and a close study of local conditions, I have been able to formulate what should be a reliable estimate of the maximum probable rate of rainfall for any period from five to sixty minutes.

More information should be obtained on this question, and I advise the establishment of ten automatic recording rain gauges in different parts of the Peninsula.

Plate 2 shows:—

(1) Estimated maximum rate of rainfall over periods from five to sixty minutes. The circles show the intensity of the heaviest storms recorded during the year 1912 at New Westminster.

(2) An analysis of the intensity of rainfall falling in one hour, computed from the New Westminster records. It is a noticeable fact that on only three days did over one-quarter inch of rain fall in one hour. This point will be referred to later.

(3) The direction of winds in English Bay averaged over the years 1910 and 1911. The horizontal lines represent weeks. Off shore winds, i.e., Easterly, are the prevailing winds.

Population.

One of the chief problems an Engineer has to deal with in the layout and design of a large sewerage scheme is of an economic nature. To construct a sewer that becomes too small for the needs of a district and has to be rebuilt before the loan under which it was constructed, is repaid, is bad economics, and it is equally bad to burden the ratepayers of to-day with a large capital outlay on a sewer that will not be called upon to do its full duty till many years after the completion of the payment of the loan.

The usual life of sewer construction bonds is forty years, but there is no reason why the works should not be in as good a condition and as capable of doing the work they were designed for far beyond this period, provided the proper skilled supervision is given in their design and construction, and proper control is exercised over the expansion of the scheme to deal with the growth in development of the outside areas. The high and low level interceptors in the Toronto Main Drainage Scheme, the largest in this country, were designed for thirty-eight years, and I propose to apply this figure to Greater Vancouver and design for the year 1950—or, to be more correct -for the population which I estimate will be resident on the Peninsula by that time.

In the case of Burrard Peninsula, Nature has fixed the limits and areas of the different watersheds, so the problem is somewhat simplified.

The forecasting of the growth of population in a well-developed and settled country is not an easy matter. In a fast developing new country such as this it becomes increasingly difficult, and really the only logical basis on which one can found an estimate is the actual growth of other cities in the past, in conjunction with such other conditions as are likely to affect the City's growth.

Plate No. 3 shows the actual rate of growth of different cities on this continent applied to Vancouver. Thus, if Greater Vancouver grows at the same rate as Boston, the population in 1950 will be 500,000; while if it grows at the same rate as Chicago, it will be 2,000,000. There is a wide difference between these figures, and somewhere between the two lies the true value of the unknown quantity. Taking into consideration the awakening of the great nations of the West, China and Japan, the construction of the Panama Canal, the railway developments in British Columbia, together with the natural harbour facilities in and around Burrard Peninsula, I do not think that I am taking an exaggerated view when

I estimate the population in the year 1950 at 1,400,000, including New Westminster. This rate of growth is between that of New York and Chicago, and is shown on the diagram. The population may not follow the curve shown; it may increase more rapidly at first and drop off later.

It is really unimportant whether the population reaches that actual figure by 1950 or not. The scheme which I will submit to you will be designed to deal with the sewage of a population of 1,217,000 persons within the present Municipal Boundaries of the City of Vancouver, South Vancouver, Burnaby, and Point Grey, together with the rainfall from the areas as then developed.

The distribution of the population is another very important point in the problem. The table below shows the present distribution and density of population on the City of Vancouver by wards.

AREA AND POPULATION OF CITY OF VANCOUVER BY WARDS.

Ward	Population	Area	Population per Acre
1	21,386	670	31.4
2	15,120	400	38.0
3	13,342	440	33.0
4	25,439	1,100	23.0
5	17,923	1,260	14.0
6	20,155	2,040	10.0
7	4,711	2,980	1.6
8	4,024	360	11.0
Total	122,100	9,250	13.2 average

These figures apply to residential population only. There is an additional "day" population which, in the down-town business section, may increase the above figures by several hundred per cent. For example, the actual density per acre in the case of the new B. C. Electric Building amounts to 1,000, while in the Rogers Building it is estimated at 1,400.

Where the combined system of sewerage is in operation, however, once the population reaches 100 per acre the size of the trunk sewer is not affected by any further increase, as the controlling factor is not the actual sewage flow, but the run-off from the rain falling on the impervious area. In other words, up to a population

of 100 per acre the surface is partly porous and a portion of the rainfall soaks away into the ground. Above a population of 100 per acre, provision must be made for dealing with practically the whole of the rainfall. These figures are, of course, used in a general sense applying to large areas.

Plan No. 4 shows my estimate of the population density in 1950. The figures given must be looked on as averages for the particular area they apply to. They give an average over the whole Peninsula of 25.2 persons per acre. The population per acre of other large cities on this continent are:—

New York	26	per acre
Chicago	18.6	" "
Pittsburgh	20.5	" "
Philadelphia	18.6	" "
Boston	26	" "
Baltimore	28.6	" "

Existing Sewer Areas.

The areas already sewered, or provided for by trunk sewers, are shown on Plan No. 10, hatched green. The sewers have been designed on varying data and on different systems and forms of construction. Many of them will have to be enlarged, or supplementary sewers constructed. The City of Vancouver has already constructed portions of the main trunk sewers, which form a part of the scheme, at Balaclava Street, Bridge Street and China Creek; and Point Grey has recently constructed a trunk sewer outlet at Kaye Road. Burnaby has under consideration a joint scheme with New Westminster for a small portion of the Municipality draining naturally through that city.

The Disposal and Collection of Sewage.

The subject of predominating importance in this investigation is the location of outfalls in the tidal bays and estuaries adjacent to the Peninsula. I believe, therefore, that it will assist in the desired appreciation of the studies leading to the conclusions, if their consideration is preceded by a discussion of the principles underlying the theory and practice of sewage disposal, with particular regard to dilution in natural waters.

No attempt will be made to qualify the general statements herein employed, by enumerating exceptions to which they may be subject, but which are of rare, rather than of fundamental importance.

The dry weather sewage of a community has been defined as its water supply after it has been used; that is to say, it is composed of clean water, carrying away with it in solution and suspension, a relatively small proportion of discarded wastes—scarcely as much as one part by weight in a thousand—under prevailing and anticipated conditions on the Peninsula. These discarded wastes are present in the sewage, in about equal quantities of mineral and organic matter. The one-half part of unstable organic matter is the potentially offensive constituent in the one thousand parts of sewage; which, as a whole, is dangerous to the public health, chiefly because there may be some disease-producing bacteria amongst the multitude of useful organisms it contains.

The organic content of sewage, in common with all dead unstable matter is eventually converted into the inoffensive mineral form by oxidation. Bacteria are the most important natural agents at work in the accomplishment of this result, by virtue of their activity and efficiency in converting organic matter to a readily oxidizable form.

When this bacterial action takes place in the presence of air, or other available sources of oxygen, the resulting products are not offensive; but after the supply of oxygen is exhausted, the process is accompanied by the evolution of foul-smelling odors, noxious gases, and other disagreeable manifestations of what has been termed putrefaction.

About one-half of the organic content of sewage above referred to, is present in solution, and the remainder as solid matter, which must, however, be liquefied preliminary to its final oxidation.

In a properly constructed sewerage system, the dissolved oxygen available in, or taken up by, the sewage, is sufficient to meet the demands of the readily oxidizable matter, and the sewage reaches the point of disposal in a fresh, and only mildly disagreeable condition. When discharged into a body of water, the soluble matter mixes with, and is diluted by the water to a varying degree; the lighter solids float, some very finely divided and semi-solid matter, differing but little in specific gravity from the water itself, is carried in suspension, while the heavier solids tend to sink to the bottom, obviously to an extent depending on the transporting power of the prevailing currents.

The floating solids are gradually broken up by mechanical forces, become waterlogged, or lose their buoyancy by the escape of entrained gases, and in a large measure sink to the bottom along with some of the particles originally in suspension.

These settled or precipitated sewage solids are commonly known as sludge; and when accumulated to any considerable depth on the bottom, the activities of the bacteria and other organisms deplete the available oxygen within the mass. Consequently, the process of decomposition, which follows, is accompanied by the production of foul-smelling gases. As a result of this decomposition, some of the organic sludge is liquefied, while the major portion is changed from its originally offensive to a stable inoffensive condition. The intensity of this action is promoted by a circulation set up in the mass of the sludge, incidental to the release of the gases therefrom; which, in their ascent through the water, carry along with them, and disperse, particles and masses of decaying sludge; and, in their subsequent escape to the atmosphere, cause the bubbling that commonly occurs at the surface of waters overlying foul bottoms.

The liquid products of the original solids diffuse through the water, and together with the organic matter originally in solution, are ultimately oxidized to inoffensive mineral forms, either directly or after conversion by the bacteria to a readily oxidizable condition.

The oxygen required for these purifying processes, though obtained to some extent by the reduction of its compounds, is derived for the most part from the dissolved oxygen stored in the water, which is replenished by absorption from the atmosphere. There is a limit to which this dissolved oxygen can be reduced without objectionable results. A higher percentage of residual oxygen is needed during the warm summer weather. Should the supply prove insufficient to maintain this safe margin of residual oxygen, the offensive conditions peculiar to putrefaction may here again prevail in time, and, in extreme cases, the diluting water will become dark colored, foul-smelling, and exhale offensive odors.

The surface water discharged from storm water drains carries large quantities of silt in suspension, which settle readily to form deposits. Washings from streets at the beginning of storms may be charged with considerable organic filth, also, but not to such an extent nor of such frequent occurrence, as to give rise to the offensive conditions resulting from the organic deposits of domestic sewage. It is possible, however, that the silt discharged from combined sewers, may, under some circumstances, be so impregnated with organic filth as to become appreciably offensive when accumulated in deposits. Deposits of both organic and inorganic matter, it is to be noted, are often responsible for the obstruction of navigable channels.

The offensive conditions previously referred to must inevitably result, to some extent, wherever the bacterial decomposition of organic matter in sewage is obliged to take place in the absence of an adequate supply of oxygen. On the other hand, when sewage is discharged into a current of sufficient strength to prevent the deposition of the heavier organic solids, or to so break up and disperse them, that any escaping complete oxidation while in suspension finally subside without concentration over a large area, the digestion of these solids takes place without any noticeable offence.

In like manner, under favourable circumstances, no offence is created in the further bacterial decomposition and final oxidation of the unstable liquid products of sludge digestion, or of the organic matter originally in solution. The essential condition to this end is: that the demand for oxygen necessary for the destruction of the organic content of sewage, shall not overtax the capacity of the diluting water to furnish it. To maintain this condition, it will not alone suffice to discharge the sewage into a body of water capable of its assimilation. Obviously, in order that the fullest advantage may be taken of the purifying agencies and properties inherent in the diluting water, the sewage must be brought under the influence of these agencies. That is to say, it must be discharged where it will be subject to such action of the currents, winds and other allied factors, as will effect its adequate dilution in the surrounding water.

So far reference has been made only to the grosser and more disagreeable pollution that may result from the disposal of sewage by dilution. There are other features of importance in this connection. Apart from the presence of floating solids of sewage origin, the discharge of a large volume of sewage into a relative clean body of water, is usually attended by an appreciable turbidity and discolouration, in the immediate vicinity of (and to a diminishing extent remote from) the outlet. Another characteristic indication of a sewer outlet is the existence of a thin film of grease or oily sleek overlying the water.

Occasionally, where large quantities of industrial wastes are discharged into the sewers, this discolouration may be intense and extensive in its effects: grease and oily wastes may also accumulate to cause very unsightly and nauseating conditions at the surface, besides interfering with the freshening of the water by aeration.

Generally speaking, however, when the discharge is into a current of sufficient strength to prevent local deposits of organic matter, the conditions, peculiar to the vicinity of a sewer outlet, are

not offensive to any considerable degree, and are objectionable chiefly because of what they imply. Floating particles of garbage, pieces of paper and fecal matter, together with the oily sleek on the surface, are of course unsightly, and, though gradually broken up and dispersed by the action of winds, waves and currents, may create a nuisance when washed ashore, or to localities devoted to bathing, boating or other forms of recreation.

So far as definite information on the subject goes, it appears that a large majority of the pathogenic bacteria, originally present in sewage, die within a week or ten days in natural waters. Some of the more resistant forms may, however, survive and retain their virulence for a much longer time. The presence of disease-producing germs in the diluting water, constitutes a menace to the public health to a degree depending on the uses to which the water is put. The chief danger arises from the possible infection of water and ice supplies and shell fish. Opportunities for the transmission of disease are also afforded to some extent in connection with bathing, boating, handling driftwood and logs, and in other pursuits common to a waterfront.

There is another feature of great importance in connection with the subject of disposal of sewage by dilution. The presence of sewage in inland or tidal waters may result in the reduction and destruction of the fish life naturally abounding therein. This may be partly due to the fish leaving a neighbourhood where the environment is, in a general way, unfavourable to them. Moreover, certain constituents of sewage, particularly that of industrial origin, may exert a direct toxic action on fish, or so affect their respiratory organs that they die of suffocation. Usually, however, the presence of sewage in natural waters is prejudical to fish, chiefly because it may be the means of depleting the supply of oxygen, below the saturation value, favourable to, or even essential for, their preservation.

On the other hand, it is to be noted that sewage may serve as the source of part of their food supply. This important service in the economy of nature is made possible by various micro-organisms, the lower assimilating the constituents of food value in the sewage and serving as a food themselves for more advanced types of aquatic life, finally developing to a form on which young fish can feed. It has been found also that under some circumstances the discharge of sewage into tidal waters is responsible for the growth of certain green seaweeds, which may become stranded on the foreshores, and constitute a nuisance by their subsequent offensive decomposition.

The whole question of the disposal of sewage by dilution in natural waters calls for the consideration, in the first place, of the objectionable conditions that may be created therein, and, in the second place, of the possibility of these conditions proving a nuisance. These objectionable features have already been discussed in detail, and may be summarized as follows:—

(1) The infection of water by pathogenic bacteria.

(2) The turbidity, discolouration and unsightly surface conditions in the vicinity of, and remote from the outlet; usually only mildly disagreeable, but occasionally decidedly so.

(3) The evolution of foul odors, and the unsightly appearance of the water resulting from the putrefaction of sludge deposits, or from the putrefaction of the organic matter in solution in the water, following the exhaustion of the oxygen therefrom.

(4) Pollution of the foreshores by the offensive decomposition of stranded sewage solids, and aquatic plants which thrive because of the presence of sewage.

(5) The introduction into the water of substances which are either toxic to fish or deprive them of the oxygen necessary for their preservation.

(6) The obstruction of otherwise navigable channels by deposits of organic solids and silt.

Consequences of this nature can always be minimized, and very often avoided altogether, by the exercise of care and judgment in locating the outfall, and in providing facilities for the proper discharge of the sewage.

It is essentially important to take the best advantage of such factors as will insure the prompt and adequate dilution of the sewage by inter-mixture with the diluting water. In so far as aesthetic nuisances are concerned, the organic solids are the hardest to deal with.

Experience and research have gone far towards establishing what degree of dilution may be safely regarded as adequate for the prevention of offensive conditions. In so far as this experience relates to the widely practiced custom of disposal in rivers, it points to the general conclusion that a flow of six or seven cubic feet per second of well aerated water, per 1000 people contributing sewage to the stream, is sufficient for its satisfactory assimilation.

Assuming that a river water is, at any point in its course, free from the elements of pollution, the quantity of sewage that can be safely discharged at this point without creating offensive conditions, obviously depends not only on the population already tributary to the river below, but on the time available for the purification of the up-stream sewage, before it enters a zone subject to pollution from the down-stream population.

Similarly, it is evident that a very low dilution may suffice for sewage discharged into a river, which in a short time empties into and merges with a relatively large body of well aerated water.

Variations in the composition of the sewage, or of the diluting water itself, may, however, introduce mischievous complications that are neither expected nor always clearly understood. It is still more difficult to predetermine the efficiency of the dilution effected by the factors favourable thereto. This is particularly true of tidal waters since the flow past the outlet is not continuous, but is periodically checked or reversed. Other modifying factors that call for attention in connection with the disposal of sewage by dilution in salt or brackish waters, are:—

(1) There is a stronger tendency for the sewage to rise and form a surface stratum in salt than in fresh water, on account of the higher specific gravity of the salt water. This retards the diffusion and dilution of the sewage, and aggravates the disagreeable surface conditions in the vicinity of the outlet.

(2) Salt water also appears to precipitate more of the finely divided colloidal matter in sewage, to add to troublesome sludge deposits.

(3) The decomposition of sludge deposits seems to be more complete and offensive in salt water, and the resulting products either directly or indirectly make a heavier demand on the dissolved oxygen stored in the water.

(4) Normally, salt water contains less dissolved oxygen than fresh water, but is capable of absorbing it at a higher rate from the atmosphere, under similar conditions affecting saturation and aeration.

The dilution required for the inoffensive assimilation of sewage by salt water has not been so closely approximated as in the case of fresh water. It is a matter much more difficult of determination from observations and studies of the results of practice. It is known that the oxidation of the sewage entering the upper reaches of some

long rivers is practically completed before it reaches other points of pollution or finally enters the ocean. On the other hand, a portion of the sewage discharged into tidal harbors and estuaries is carried out by the tides in only a partially fermented condition; moreover, the re-aeration of the waters remaining at low tide by the more highly saturated waters of the rising tide, and the inflow of varying quantities of land water add to the complexity of the circumstances as a basis for determining either the degree of the dilution or a measure of the purification thereby effected. It would appear, however, that fresh water has a greater capacity than salt water for the inoffensive assimilation of sewage.

Another subject with regard to which conflicting opinions are held by those most familiar with it, is the safe margin of residual dissolved oxygen that must be maintained for the preservation of fish life in either fresh or salt water. All are agreed that a higher saturation percentage is required for the more active species, differ widely in an estimate of this percentage.

I do not propose to advance definite statements with respect to a disputed subject, or to question the reliability of conclusions deduced from special investigations of the principles involved. However, considering the capacity of fresh water for the digestion of sewage, and making due allowances for the effects of the dissimilar properties of salt water, it would seem that a dilution of from one in seventy to one in a hundred should be sufficient to prevent offensive results following the discharge of sewage of ordinary strength into well aerated sea water; and that a dilution of from one in a hundred to one in one hundred and twenty-five should be adequate for the protection of major fish life in fresh and salt water.

It will be understood that the previous remarks are of a general character and do not apply to offensive conditions arising from the putrefaction of subsided organic solids, or to those conditions which are objectionable in appearance only.

Assuming that any or all of the objectionable features already referred to, do prevail, the degree to which they can be said to constitute a nuisance depends on the uses to which the waters and shores are put, and on the density of, and proximity thereto, of human habitations. For instance, to cite an extreme case: a river might be intensely polluted by the sewage from a community without causing a nuisance, provided it flowed away to the sea through an uninhabited country, was not navigable, nor suitable for purposes of recreation, and was not, in its natural state, frequented by fish.

Usually, however, the existence of pollution establishes a nuisance, either in: (1) the hygienic sense, such as the infection by pathogenic bacteria of water supplies, ice supplies, shell fish, bathing waters, and, of less importance in this sense, the nuisances due to the foul odors of putrefaction; or in the (2) aesthetic sense, that is, arising from conditions that are offensive to the senses, such as floating solids of evident sewage origin, grease, scum, discoloured waters, and putrefactive odors; and, finally, in what may be called the (3) economic sense, the most important of which are the destruction of fish life and the obstruction of navigable channels.

Some idea of the quantity of suspended solids discharged from sewers can be formed from an estimate submitted by the New York Sewerage Commission with respect to the sewage of that city. These Commissioners estimate that for each thousand persons tributary to the sewers, forty-five tons of suspended solids are discharged annually. Moreover, the forty-five tons of solids, when mixed with the harbor waters, form over 2,200 tons of wet sludge, having a bulk of approximately 2,500 cubic yards.

When it becomes impossible, or economically impracticable, to dispose of sewage by dilution, without creating a nuisance of some kind, recourse must be had to such artifical treatment of the sewage as will eliminate the particular features and constituents responsible for the nuisance.

Where the nuisances are caused by floating matters, screens and grease interceptors are provided for their separation. When silt is the objectionable feature, blocking the outfall pipe or channels in the vicinity of the outlet, it can be removed by passing the sewage through a grit chamber, with reduced velocity to allow the silt to subside. When, as frequently does happen, the trouble is due to sludge deposits, the sewage is passed very slowly through sedimentation basins to effect the removal of all but the very finest of the suspended organic matter; occasionally chemical precipitants are used to assist in the sedimentation.

The necessity of keeping the sewage in a fresh state limits the duration of the sedimentation period, and about one-third of the organic matter, together with about the same proportion of bacteria can be removed by plain sedimentation. The removal of the heavier organic solids simplifies the problem of disposal with respect to the formation of troublesome sludge deposits, and also to a less extent with respect to the degree of dilution required for the satisfactory assimilation of the sewage. When the available quantity of diluting water is incapable of effecting this latter purpose, the load on the

water must be lightened by the oxidation of the organic matter in the subsided sewage, preliminary to its final discharge. That is to say, the sewage must be submitted to a process of so-called purification.

Broad Irrigation, or sewage farming, was one of the earliest methods adopted for this purpose. It originated and has had its most extensive application in England. Later, an allied method, known as "Intermittent Filtration," came into practice in the New England States. The natural sandy formation there permits satisfactory treatment at a higher rate than is favourable for the cultivation of most crops.

Both of these methods have been continued where large areas of suitable land are available. Still later, Contact Beds, and more recently, Sprinkling Filters, were developed in England and have come into general recognition. The filtering medium in both types consists of some such easily procurable material as broken stone. Their method of operation, however, is entirely different.

With Contact Beds, the sewage is admitted to the tanks containing the filtering medium, and is retained there for sufficient time to permit the desired sedimentation, bacterial action and oxidation; the sewage is then drained off, and further opportunity is afforded for the digestion of the retained solids, by allowing the tank to remain empty for a time, before re-charging. Where the degree of purification requires it, the whole process is repeated on secondary beds. The effluent is acceptably clear, and, more important still, is oxidized to a stable condition. The bacteria also are largely reduced.

In Sprinkling Filters, the sewage is sprayed over a coarser medium, through which it freely percolates. The effluent from these filters is oxidized to a condition of stability, and the bacteria largely reduced. The effluent is not clear, but the solids still in suspension are relatively stable and readily subside with a few hours' sedimentation. Preliminary clarification is favourable to the successful and economical operation of Contact Beds, Sprinkling Filters, and to a less extent Intermittent Sand Filters.

Sprinkling Filters and Contact Beds have largely superceded the earlier land treatment methods, chiefly because the comparatively small area required has made their general adoption possible. Sprinkling Filters are a marked improvement over Contact Beds in this respect.

The very great disparity in the areas—it is usually found necessary to provide for the various methods of purification—can be

fairly represented by stating that the sewage which would require 200 acres for its disposal by Broad Irrigation, can be treated on 25 acres by Intermittent Filtration, on two to three acres in Contact Beds, and on one acre of Sprinkling Filters.

With respect to the character of the effluent produced, the modern methods do not compare with the earlier land treatments. The effluent from a well conducted sewage farm approximates the quality of a good drinking water. The effluent from Intermittent Filters is not quite so good, although all but one or two per cent. of the bacteria are removed, and in appearance it is all that can be desired.

Contact Beds and Sprinkling Filters, in conjunction with proper facilities for screening and subsidence, can nevertheless produce a stable effluent of satisfactory appearance, that is to say, there is little likelihood of it becoming offensive to the senses, and it can be safely discharged into a harbour or stream, without danger of creating a nuisance in either the aesthetic or commercial sense.

Very often, however, bacterial contamination is the chief objection, and at times the sole objection to the discharge of crude sewage into natural waters. It has already been pointed out that sedimentation and the different processes of purification are effective to a varying degree in removing the bacteria. Moreover, subsided sewage may be sterilized by treatment with some such disinfectant as "Hypochlorite of Lime." This treatment may be applied, either in conjunction with, or without, any of the processes of purification, according as it may be necessary or expedient from economical reasons to do so. Where the sewage is charged with trade wastes, more elaborate clarification plants or special processes may be required for its treatment.

In short, it is possible, by artifical treatment of sewage, to effect almost any desired degree of purification. It is largely a question of expense.

Apart from the initial cost of the works, their successful operation requires more intelligent attention, and entails a greater expense, the further the purification is carried. Moreover, the operation of a disposal plant in the vicinity of human habitations is subject, usually to sentimental, and occasionally to real objections.

Where inland and tidal waters are available for the convenient disposal of sewage by dilution, obviously the logical method of procedure is to utilize the natural purifying agencies and properties

inherent to these waters in so far as it can be safely and satisfactorily done; resorting to artificial treatment for the removal of only such pollution as may interfere with the accomplishment of this result.

The tidal bays and estuaries surrounding the Burrard Peninsula are destined to become by necessity and adaptability the scene of extensive harbor developments and commercial activity. The extent to which it can be safely planned to make use of them for the disposal therein of sewage on the Peninsula, is limited in part by the standard of cleanliness that should be maintained around a busy water front.

The Metropolitan Sewerage Commission of New York has during the past six years conducted a most exhaustive investigation, partly for the purpose of establishing such a standard for New York harbor. The New York Bay Pollution Commission had previously made a study of the situation on somewhat similar lines from 1903 to 1906. At the instance of the Board of Apportionment, an independent enquiry was undertaken in 1909 and completed two years later.

The Metropolitan Commission had the staff, means and facilities at their disposal, to carry out on a large scale many experiments and tests, having an important bearing on the effects produced by the discharge of sewage into tidal waters. The five members of the Commission were men of wide experience and of recognized ability, and they had the benefit of the independent opinions of eight experts, selected from the best in the profession, including a leading authority on harbor pollution from the Old Country.

Considering the scope and nature of the enquiry, the views of the New York Commission as expressed in their recommendations, submitted a few months ago to that corporation, are worthy of the highest consideration and will be quoted here in so far as they apply to conditions covered by this investigation.

General Recommendations of the New York Sewerage Commission as to the Degree of Cleanliness That Should Be Maintained in the Harbour Waters.
August 12, 1912.

1. Garbage, offal or solid matter recognizable as of sewage origin, shall not be visible in any of the harbor waters.

2. Marked discoloration or turbidity due to sewage or trade wastes, effervescence, or oily sleek, odor or deposits, shall not occur,

except in the immediate vicinity of sewer outfalls, and then only to such an extent and in such places as may be permitted by the authority having jurisdiction over the sanitary conditions of the harbor.

3. The discharge of sewage shall not materially contribute to the formation of deposits injurious to navigation.

4. Except in the immediate vicinity of docks and piers and sewer outfalls, the dissolved oxygen in the water shall not fall below 3.0 cubic centimeters per litre of water. Near docks and piers there should always be sufficient oxygen in the water to prevent nuisance from odors.

5. The quality of water at points suitable for bathing or oyster culture should conform substantially as to bacterial purity to a drinking water standard.

There are two recognized systems for collecting and conveying to the point of disposal the domestic and industrial wastes of a community, and the surface water from its drainage area.

(1) The separate system, where the domestic and industrial waste are kept entirely separate from the surface water flow, separate channels being provided for each.

(2) The combined system, where the domestic and industrial wastes and the surface water flow into one common sewer.

In a report to the Joint Committee on May 31, 1912, I referred to the question with special reference to English Bay and False Creek areas, and I expressed myself as being in favor of the principle of the separate system for these areas, inasmuch as it permits of fuller advantage being taken of the Main Drainage Scheme in keeping False Creek and the foreshore of English Bay unpolluted.

In the design of a large sewerage system such as this, the Engineer is confronted by two distinct problems:—

(a) The collection and disposal of the domestic and trade liquid refuse of the community, defined as sewage.

(b) The collection and disposal of the rainfall running off the paved and impervious surfaces, defined as surface water.

In the first case, the **collection** is a comparatively simple matter, as the quantity of sewage from any given area can be accurately ascertained and estimated, while the disposal of the collected sewage without nuisance or injury to public health is often a matter of considerable difficulty; in the second case, the conditions are reversed, the **collection** of the surface water is the principal problem, its disposal, as it is practically unpolluted, being a comparatively simple matter.

The relative amounts of surface waters and sewage vary, of course, with local conditions. On Burrard Peninsula, taking an average area of, say, one thousand acres and a population of forty per acre, it would be necessary to provide a channel with a capacity of fifteen cubic feet per second to deal with the maximum sewage flow; but to take off the maximum flow of surface water from the same area, a channel capacity of five hundred cubic feet would be required.

Now as to the disposal of these two liquids. The sewage, which is of small volume and constant flow but highly polluted, and the surface water, which is of large volume, occasional flow and comparatively innocuous.

It is obvious that surface water can be discharged into many natural channels and under conditions where the discharge of crude sewage would be highly objectionable.

Take for example, False Creek, Burnaby Lake and the many creeks draining to English Bay and the Fraser River; all these can be utilized for the disposal of surface water. Of course, as a district develops, land becomes valuable and the creeks have to be culverted and filled in. But, provided the culverts are properly designed, there is no reason why these creeks should not continue to carry out the functions that Nature constructed them for, that is, the removal of surface water from their natural drainage area.

The disposal of the sewage is a very different problem, and in the case of English Bay and False Creek areas, it is necessary to intercept it by an expensive sewer and outfall to carry it to a point off Imperial Street, where it can be disposed of by dilution and dispersion without nuisance or injury to public health. The North Arm of the Fraser River can digest the small quantity of sewage which now discharges there, but as the contributary population increases, the sewage flow will increase, and a time will undoubtedly come when either an interceptor will have to be constructed or some form of treatment adopted.

As I stated in my previous report—modern practice where sewage has to be treated or carried long distances by interceptors, favours the separate system.

The chief argument against the adoption of the separate system is on the ground of the alleged greater expense it involves; and, as a general proposition, it is true that with a common outlet it does cost more to construct a system of separate sewers and storm water drains than to construct a combined system. What this extra

expense may amount to in any particular case, however, depends on the extent to which local conditions may introduce modifying factors that tend to equalize the costs. In this connection it is to be noted that:—

(1) A system of surface water drains may be less extensive than a system that has to provide for the removal of sanitary sewage, depending on the gutter grades and the intensity of rainfall.

(2) Inasmuch as the minimum depth to which surface water drains must be laid, is governed by considerations of depth of cover rather than provisions for house drainage, the excavations for these conduits may be much less where the separate system is adopted.

(3) Moreover, since the consequences that may follow overcharging during excessive storms are not likely to be so disastrous and objectionable in the case of a surface water drain as from a combined sewer, it may not be necessary in some instances to provide the same capacity for surface water, where the separate system is adopted, as might seem desirable with the combined system.

(4) A somewhat cheaper construction may be permissible in a surface water drain than in a combined sewer, considering that the drain is not subject to the same scouring action, that the objection to worn surfaces and leakage are not usually so serious in a drain as in a sewer, and, finally, that better opportunities are afforded for the repair of a conduit in which the flow is only periodical.

It must be remembered that the previous discussion does not take into consideration special provisions for the disposal of sanitary sewage.

Whilst nearly every modern Sanitarian admits that the separate is the better system, it is looked on as somewhat of a luxury. It must not be forgotten, however, that the luxury of to-day becomes the necessity of to-morrow, and in considering a scheme of this magnitude, the trend of modern practice must be taken into account rather than the actual methods in use at the present time.

In Germany, one of the pioneer countries in sewage disposal work, it has been largely adopted. In Boston, in 1903, an Act was passed forcing estate owners to construct a surface water drain and a sanitary sewer, and giving the Municipalities power to expend one-twentieth of one per cent. of their taxable valuation, outside the statutory debt limit, in the construction of the separate sewers. In

the new Federal Capital of Australia, the separate system has been adopted. On the other hand, the British Royal Commission on Sewage Disposal expresses the opinion that the system is impracticable for large towns. Conditions in England, however, are very different to conditions here, and even there the trend of opinion is shown very markedly in a recent discussion on the Glasgow Main Drainage Works, where Maurice Fitzmaurice stated in effect that they had nearly trebled their original allowance per acre for storm water during the last ten years.

It would be difficult at this time in advance of complete subdivisions and street profiles, to submit a reliable comparison of the initial costs of the separate and combined systems over the whole Peninsula, or even on those areas where the separate system is recommended. It can be said, however, that the conditions tend to equalize the first costs of the two systems, particularly in so far as good grades and moderate intensity of rainfall are conducive to this end.

There is another way in which the separate system will prove more economical, and that is in deferring capital expenditure. The conditions on the Peninsula are such that in many localities the removal of surface water is not of such a pressing necessity as the removal of the sewage, and in many cases the construction of the surface water trunks could be deferred.

The particular advantage of the separate system in the case of English Bay and False Creek areas is that it will prevent the pollution of the foreshore by domestic sewage. A reference to the meteorological sheet will show that, roughly speaking, rain falls every other day, and although the proposed interceptor is designed to take all but the heaviest storms (occurring, say, three times a year) from the area at present drained on the combined system, the adoption of the combined system as a whole would mean a gradual increase in the number of occasions in which the interceptor would not take the flow from the combined trunks, until eventually the trunks would be discharging dilute domestic sewage on three days out of seven.

Reference has already been made to the standards of purity laid down by the New York experts who state the standard required for bathing places should approximate that required for drinking water.

Studies of Waters in and Around the Peninsula.

I will now put before you in detail the observations made and the conclusions to which I have come in studying the bodies of

water in and around the Peninsula. Particulars of their areas and depth are given in Plans Nos. 8 and 9. It will be convenient to discuss each in detail with reference to:—

(1) Their capacity for the digestion of sewage;
(2) The standard of purity desirable;
(3) The most suitable position of point of outfall.

English Bay.

Capacity. East of a line between Point Atkinson and Point Grey, English Bay has a high water area of 21 square miles, with a maximum depth of over 300 feet.

It is hardly fair to assume that the whole of this bay is available for Greater Vancouver. The North shore districts have an equal interest, and for the purposes of my calculations I shall take that part of the bay inside a line drawn from Point Grey to Siwash Rock—within these limits there is an area of six square miles, with an average depth of 40 feet, and a tidal volume on a 10-foot tide of over 10,000 million gallons. Now, ignore altogether the permanent low water volume and take into consideration only the above tidal volume on this one-third part of English Bay which is brought in twice a day. It will digest on the basis of a 1/100 dilution the sewage from 2,000,000 people without nuisance or injury to fish life. It will be seen, further on in this report, that the estimated 1950 population discharging sewage to the bay is but 270,000. With the immense quantity of water available for dilution, the only nuisances likely to occur would be those of an aesthetic nature, and proper provision will be made for intercepting all floating matter.

The Fraser River has a very important and beneficial effect on English Bay from a sewage disposal point of view. Plan 6a shows the percentages of land water present in the bay at low and high water of the Fraser River on the rising and falling tide and on the surface and at a depth of 10 feet. It will be seen that during the time of high water of the Fraser (i.e., the summer months) there is a layer containing a high percentage of land water over the bay. Experiments at New York shewed that when sewage was discharged into a mixture of 85% land water, it was in equilibrium, that is to say, it neither rose nor fell. I believe that this top layer of land water will check the rise of sewage to the surface, if it does not altogether prevent it.

There is one more point to note, and that is the possibility of future harbour developments involving the construction of a breakwater out from the Point Grey foreshore.

Standard of Purity. The standard of purity demanded for the foreshore of English Bay is high, owing to the presence of bathing beaches, and the fact that it is the only shore on the Peninsula really suitable for purposes of recreation. As before mentioned, the standard fixed by the New York experts for waters of this class is that it should approach the purity of drinking water.

Point of Outfall. Numerous float experiments have been made with a view to determining the point of outfall where the best diffusion could be obtained. It was found that the principal factors giving rise to the currents in English Bay were the Fraser River and the wind—the tides having comparatively little effect.

The Fraser River, during its high season, causes a definite current across from Point Grey to the First Narrows at all stages of the tide. The effect is less marked during the low season.

Between this line and the shore—there is at all times a circular clockwise movement of the water—the general run of the surface currents during the high season of the Fraser is shewn on Plan No. 5. The First Narrows is, of course, from a dispersion point of view, the ideal point for discharge. Estimates of cost were carefully gone into, and although the actual cost of carrying an outfall there is not prohibitive, it was considered that equally good results could be obtained by discharging at a more accessible point.

On the line of Imperial Street, some 5,000 feet out, was eventually fixed as the most suitable point of discharge. A large number of floats were started from this point; their limits of travel, after various periods, are shewn on Plan 6, which also shews the limits of travel of floats set out from Point Grey during the high stage of the Fraser. The possibility of the construction of a breakwater running out from the Spanish Bank has not been lost sight of, and the interceptor is at such a level as to permit of extension to Point Grey.

False Creek.

Capacity. False Creek has an area at high water of nearly 1½ square miles, while the area at low water is just under one-half square mile. The amount of water entering on a 10-foot tide is about 1600 million gallons.

At the present time False Creek is in a very undeveloped condition. It is probable that eventually the upper end will be filled in and the remainder dredged and deepened, the large expanse of mud flats visible at low water being removed. Whatever may be done in the future, False Creek will always remain a small, comparatively

shallow body of water in the midst of a thickly populated district—diffusion will be poor, owing to the lack of through currents. Moreover, right out at the mouth of the creek, on either side, are the Kitsilano and English Bay bathing beaches, and this fact alone is sufficient to condemn it as a suitable place for the disposal of crude sewage. False Creek can, however, play a very useful part as a relief outlet in times of occasional heavy storms to those areas where the combined system is in operation. This will be referred to later.

Standard of Purity. The standard of purity desirable for False Creek is governed by the presence at the entrance of the bathing beaches mentioned above, and should, as in the case of English Bay, approach to that of drinking water. It is, of course, a physical impossibility to attain to this standard, but all reasonable means should be taken to keep the creek unpolluted, both as regards the discharge of sewage and the throwing overboard of garbage and offal from vessels lying in the creek, and from the premises abutting on it.

Burrard Inlet.

Capacity. The areas and tidal volumes of Burrard Inlet are:—

	Area H. W. Square Miles	Tidal Volume 10-foot rise
Between First and Second Narrows	7.6	12,000 million gallons
Above Second Narrows	16.0	27,000 " "

In considering the capacity of Burrard Inlet for receiving sewage, the possibility of the construction of a dam at the Second Narrows must be taken into account. Consequently, I prefer to take the tidal volume between First and Second Narrows as the amount of water available for dilution. This 12,000 million gallons will, on a dilution of 1 to 100, effectively oxidize, without nuisance or injury to fish life, the sewage flow from a population of 2,400,000 people. The North shore has a half interest in Burrard Inlet, so I will divide this figure by two, and say that the tidal volume of Burrard Inlet, between the First and Second Narrows, can digest with proper dispersion the sewage of 1,200,000 people on the Greater Vancouver Sewerage area.

As in the English Bay calculations, the permanent low water volume is ignored, as is the 27,000 million gallons above the Second Narrows which would be available unless the Second Narrows dam was constructed.

The estimated 1950 population discharging to the Inlet is 565,000.

No sewage should be discharged into Coal Harbor on the shore line between Brockton Point and the C. P. R. wharf, as there is little through current in this locality, and a tendency for the water to become stagnant. I am making provisions for intercepting the sewer outfalls at present discharging between these points, and carrying them across to the North-east shore of Stanley Park.

Standard of Purity. The standard of purity demanded for Burrard Inlet is, in the absence of bathing beaches, not so high as in English Bay, and the calculations of dilution prove that there is an ample margin of safety. The interception of floating matter is, of course, desirable, but is not a necessity.

Point of Outfall. There are many localities along the water front suitable for points of outfall—the line of Clark Drive is the most convenient for the principal outfall. There are numerous other points where the smaller areas could discharge—the outfall pipes should be carried beyond the pier line into deep water.

Fraser River.

Capacity. The minimum discharge of the Fraser River is in the month of March and amounts, at Hope, to about 20,000 c.f.s. The maximum discharge, which occurs in June, is about 400,000 c. f. s. The discharge at New Westminster will be considerably above these figures, but in the absence of reliable records, I prefer to take 20,000 c. f. s., or about 10,000 million gallons per day.

Just below New Westminster, the North Arm strikes off the main river. The rise and fall of the tide makes the determination of the proportion of flow down each of these channels a difficult matter. I estimate that the North Arm flow will, under present conditions, never be less than 1,000 million gallons per day, which amount, on a 1 in 100 dilution basis, will deal with the sewage flow from 100,000 persons.

The minimum flow of the main river would, on the same basis, oxidize the sewage flow of 900,000 people. The construction of harbour and dock works might necessitate the reduction of flow down the North Arm, and I do not at the present time feel in a position to make any more definite statement than that the Fraser River and the North Arm will be capable of dealing with any sewage that can be discharged there during the next five years.

Standard of Purity. The standard of purity should be such that no ill-effects are produced on fish life, and as far as present knowledge goes, a 1 to 100 dilution is perfectly safe.

Points of Discharge. The outfalls should be carried well out into the stream to obtain effective dispersion. For the Brunette River outfall, the best point available is near the Municipal Boundary, and for the North Arm area there should be some eight or ten outfalls along the bank between New Westminster and Eburne.

Burnaby Lake.

Burnaby Lake has a mean water area of about 430 acres, about two-thirds square mile, with a minimum depth of seven feet. I should place its capacity at about 70 million cubic feet, or, say, 500 million gallons. After a spell of dry weather it is practically stagnant, and is quite incapable of digesting any considerable amount of raw sewage.

Description of Proposed Works

It will be convenient to describe the proposed works area by area, under the following headings:—

(a) English Bay and False Creek area.
(b) Burrard Inlet area.
(c) Burnaby Lake area.
(d) Fraser River area.

English Bay and False Creek Area.

This area is shown in Plan No. 10 in brown. It comprises an area of 8,650 acres with a combined population of 270,000, distributed among the different Municipalities as follows:—

	Area in acres	Estimated Population in 1950
City of Vancouver	2,750	127,000
Point Grey	5,100	119,000
South Vancouver	800	24,000
Total	8,650	270,000

This area is one of those for which, in my previous reports, I have expressed a preference for the principle of the separate system of sewerage. The advantages of this system have already been fully discussed.

Certain areas have already been sewered on the combined system, and, while I do not propose to interfere with these areas at present, the combined system should be rigorously confined to its present limits and all extensions put in on the separate system. The English Bay and False Creek interceptor is designed so that, notwithstanding these combined areas, the system will, in practice, approximate, as far as its effect on False Creek or English Bay is concerned, to the separate system, in as much as it will only be in times of rare heavy rainfall of over a quarter of an inch per hour that the storm water overflows will come into action.

A reference to the Meteorological diagram shows that in 1912 this would have been only three times in the course of the year.

As already pointed out, the most suitable point of discharge for this area is some five thousand feet out from the shore on the line of Imperial Street.

The outfall pipe (60 inches in diameter) would be carried out at first to a distance of three thousand feet. As the population on the area increases, extensions of this pipe would be necessary to obtain proper diffusion of the sewage, arrangements would be made for the interception of all the floating matter which might be liable to be carried back to the foreshore by certain winds. The record of winds during 1910 and 1911, given on Plate No. 2, shows that the prevailing winds are offshore.

Several different routes have been examined for the line of the interceptor, and one following the foreshore, called the "Foreshore Line," and another in tunnel through Kitsilano Hill, called the "Tunnel Line," have been selected as the best two. The Foreshore Route is the cheaper and has much to recommend it. There are certain obstacles in the way of foreshore rights; these could be easily overcome, as the sewer will be in such a position and of such construction that it will form a protection to the property without, in any way, interfering with its future development, either as a residential or commercial district. The sewer would be utilized as a retaining wall, and the Marine Drive continued from Imperial Street along the foreshore to Kitsilano Beach. The sewer would be nine feet internal diameter, with an invert elevation 93 feet above City datum, and the grade would be 1 in 2700. Commencing from Imperial Street, the foreshore line would follow high water mark, being carried around the small bay in front of the Jericho Club. At Balaclava Street the size and grade would change to eight feet and 1 in 2400, respectively. Continuing along the foreshore to Balsam Street

it would then strike across the park to the corner of Yew and Cornwall Streets, then up Yew to First Avenue, and along First Avenue to the C. P. R. tracks, following the tracks under the Granville Street bridge, and swinging round into Sixth Avenue. This portion of the route is subject to the agreement of the C. P. R. There is an alternative line in tunnel. The sewer would continue down Sixth Avenue to Heather Street, and at this point the Bridge Street area would be picked up.

I will now describe the alternative route on the Tunnel Line. Starting from Imperial Street, the sewer would follow the shore line and strike across the Government Reserve into Point Grey Road The size would be 7′ 6″, one in 1,000 grade. At Balaclava Street the size would change to 6′ 6″. The line would continue along First Avenue to Yew Street, where it would swing across under private property to the corner of Arbutus Street and Second Avenue. It would continue along Second Avenue to Fir Street, where it would swing round in a South-easterly direction, crossing Granville Street and running to the junction of Sixth Avenue back lane and Birch Street. It would then follow the back lane to Bridge Street, where the Bridge Street area would be picked up.

Almost the [illegible] of this line is in deep tunnel. There are certain shallow pl[illegible]ere shafts would be sunk, from which the tunnels could b[illegible]nomically driven.

This interceptor is designed to take the sewerage flow from the estimated population in 1950, together with the surface water of the ordinary storms from the areas at present sewered on the combined system. There are several trunks draining to this interceptor, and it may be well to state here that I define a trunk as any sanitary or surface water sewer which deals with the sewage or surface water flow from an area of 400 acres or over.

The main trunk sewers in this area are:—

(a) Imperial.
(b) Alma.
(c) Balaclava.
(d) Maple.
(e) Bridge.

In addition to the above, there are two low level areas, the sewage from which will have to be pumped up to the interceptor. They are:—

(f) Kitsilano Beach area, and the
(g) Low level area, Bridge and Main Streets, South of Lansdowne Street.

Imperial Street Area.

All of the 720 acres of this area lie to the West of Imperial Street in Point Grey. The estimated population for 1950 is 14,400. Commencing at the interceptor, this trunk will run South along Imperial Street to Sixth Avenue. The area should be sewered on the separate system.

Alma Street Area.

Six hundred and eighty acres between Imperial Street and North of the natural divide in Point Grey, and 130 acres in the City, are included in this area. The trunk starts from the interceptor at the East boundary of the present Jericho Club property and runs in a South-westerly direction to the junction of Alma Street and Fourth Avenue. The exact location to this point depends on the method of sub-division in the Government Reserve, which is now being cleared for sub-dividing. This area also should be sewered on the separate system.

The Balaclava Area.

This area comprises some two thousand five hundred acres, with an estimated population in 1950 of 93,000. Commencing from the interceptor, the sewer will run South on Balaclava Street to Sixteenth Avenue (a portion of this has already been constructed by the City of Vancouver), East on Sixteenth to MacDonald, North on MacDonald to Eighteenth, East on Eighteenth to Trafalgar, North on Trafalgar to Chaldecott, East on Chaldecott to Yew, and North on Yew almost to the Bodwell Road, where the contributing area reaches the limit of 400 acres.

The principal branches from the main trunk would run on Broadway to Balsam Street, thence South to Tenth Avenue.

Maple Street Area.

This area is already sewered on the combined system, discharging through a four-foot sewer down Maple Street. This sewer will be connected to the interceptor, which will take all but the heaviest storms.

Bridge Street Area.

The Bridge Street area comprises some 2500 acres, of which 2340 acres are drained by gravitation to the interceptor. The remaining 160 acres is a low level area.

Parts of this Bridge Street area, both in the City and in Point Grey, have already been sewered on the combined system, but, as I have already pointed out, these combined areas should be confined within their present limits.

Commencing from the interceptor at Sixth Avenue and Heather one line of the sewer would follow the creek in a South-westerly direction to Broadway, and then South up Laurel to King Edward Avenue. The other branch would start from the interceptor at Bridge and Sixth Avenue, run South on Bridge to Fourteenth Avenue, East on Fourteenth to Yukon, South on Yukon to Nineteenth Avenue, East on Nineteenth to Columbia, and South on Columbia to McMullen Avenue. The best site for the pumping station, to deal with the low level area, would probably be in the neighbourhood of the Garbage Destructor.

Burrard Inlet Area.

The areas discharging to Burrard Inlet are shown on the plan in pink and blue. The greater part of these areas drain naturally to False Creek and Burnaby Lake.

The principal outlet will be at Clark Drive. There will be smaller outlets at Stanley Park and Hastings Park and other points along the water front. In the event of False Creek being filled in, I think it may be possible to drain this area also to Burrard Inlet, together with that portion of the City lying between Pender Street and the Creek, shown uncoloured on the plan.

Clark Drive Outfall.

The area discharging at the Clark Drive outfall is shown in blue, and the distribution and the estimated population of the different Municipalities is set out hereunder:

	Area in acres	Estimated Population in 1950
City of Vancouver	2,500	90,000 + 63,000
South Vancouver	3,300	99,000
Burnaby	2,450	49,000

As will be seen from the plan, part of this area drains naturally to False Creek and part to Burnaby Lake. The treatment of the former area depends entirely on what is done with that portion on the Creek lying East of Main Street bridge. Apart from any question of sewerage, if it is filled up it will be necessary to make pro-

vision for dealing with the surface water, or, in other words, China Creek will have to be continued from its present outlet, through the fill to the open water.

In any case, it will be necessary to carry a sewer to deal with the sewage flow across to Burrard Inlet, and it will, I think, be better to make this sewer of such a size as will take not only the sewage but the ordinary surface water. To put it another way, if China Creek is to be extended, it will be better to extend it to the Inlet rather than to Main Street bridge. Questions of economy, however, demand that this extension should be designed to take only ordinary storm flow, and in filling in the Creek suitable provision should be made for a relief outlet which would only come into use should the Clark Drive outfall become gorged by a heavy rainfall.

The cost of this Clark Drive outfall, or a proportion of it, should be charged against the False Creek improvement, as it will relieve that improvement of a long length of expensive culvert.

The outfall pipe would be carried well out into deep water at the end of Clark Drive, and arrangements would be made for intercepting all floating matter.

It would run South down Clark Drive to Fifth Avenue, where it would cross under the Great Northern tracks. The area lying to the East of the head of False Creek is already mostly sewered and discharging into False Creek. These sewers would be cut off by the interceptor. From Fifth Avenue the main line would swing across into Keith Drive, running South to just past Ninth Avenue, where it would turn into the Creek and run in a South-easterly direction to Clark Drive and Eleventh Avenue. From this point it would follow the Creek to Twelfth Avenue and along Twelfth to Victoria Drive. The line would then run round the South side of Trout Lake into Twenty-second Avenue, crossing the natural divide just West of Renfrew Street. From this point onward only sewage would be taken.

The main sewer would run South on Renfrew to the Municipal Boundary, where it would cross under the B. C. Electric tracks, following the Creek in a South-easterly direction to the junction of Boundary Road and Vanness Avenue, taking at this point the population on some 450 acres in Burnaby.

There would be several important branch trunks off this line. The first would start from the Great Northern crossing at Clark Drive, following the cut to Slocan Street and running East to Boundary Road and Thirteenth Avenue. From this point it would

follow the contour of the ground in a South-easterly direction, terminating at the Pole Line Road, just North of Walker Avenue, where the contributing area would be about 400 acres. The whole of the area dealt with by this trunk sewer drains naturally to Burnaby Lake, and, in accordance with the principles laid down, it would be a sanitary sewer, taking sewage only.

Stanley Park Outfall.

This outfall would discharge into the rapid current on the North-east shore of Stanley Park. It would run across the low area in the Park to the North shore of Coal Harbor, crossing the harbor in the proposed causeway to the foot of Georgia Street; here it would divide into two branches, one running up Georgia, intercepting the sewage, at present discharging to Coal Harbor, at Dunsmuir Street and Gifford Street; and the other striking across on the line of the Park limits to Beach Avenue, where the sewer at present discharging on the East shore of Stanley Park would be picked up.

The Georgia Street branch should be eventually extended to Burrard Street and the dry weather flow of the existing sewer picked up. An overflow from the present combined sewer is permissible at this point at the present time.

West of Burrard Street, as already mentioned, no sewage should be discharged, and sanitary sewers should be laid and connected to the Stanley Park outfall. The same remarks apply to the area lying to the North of False Creek, and an interceptor should be laid along Beach Avenue and sanitary sewers connected to it. The sewers above discussed are relatively small and do not come within the scope of this report (except for that part of the interceptor shown on the plan), but the prevention of pollution of the bathing beaches at English Bay and the foreshore of Coal Harbor is of such importance that I thought it well to refer to it.

Hastings Park Outfall, Etc.

This outfall and trunk drain an area of 800 acres. There will be various similar areas along Burrard Inlet water front, but they will fall below the limit of 400 acres, and are outside the scope of this report. The outfall pipe should in each case be carried out to deep water and floating matter intercepted.

Burnaby Lake Area.

The total area draining naturally to Burnaby Lake amounts to some 17,000 acres, or nearly 26 square miles.

As I have already pointed out, this area resembles a large dish, with a single outlet—the Brunette River. At the present time the sides and bottom of the dish are covered with vegetation and soil of an absorbent nature, which retains the rain and retards a large percentage of the run-off. By the year 1950 the assumed population on this area is some 200,000 people, and a considerable change will have taken place in the nature of this covering—streets and roofs will have taken the place of trees and undergrowth. I estimate that with the heaviest storms the run-off from this watershed will then be at least 4,000 cubic feet per second, that is to say, assuming a velocity of flow of five feet per second and a depth of ten feet, a channel 80 feet wide would have to be provided. It is of the utmost importance that the natural drainage channels of this district should be conserved and some sound policy of developing them to meet the demands of the future adopted. I have included in the estimates for "Immediate Construction" a sum of $200,000 for improving Still Creek and the Brunette River, and providing for such drainage as may be necessary during the next five years.

To meet the needs of the district during the next five years for sewerage facilities, two interceptors have been provided, one discharging to Clark Drive, which has already been described, and the other to the Fraser River, near the Brunette mouth, designed, like the previous one, to take sewage only. Commencing at the City Boundary, it would run as shown on the plan and intercept all sewage from Still Creek, Burnaby Lake and Brunette River.

As to the ultimate disposal of the sewage, quite recently the public health authorities have given permission to New Westminster to discharge their raw sewage into the Fraser, provided no nuisance is caused. I see no reason why permission should not be given to discharge the sewage from this interceptor—with the same proviso. But there may come a time when some form of treatment will be necessary.

Fraser River Area.

The acreage and estimated distribution of population of the area draining the North Arm of the Fraser River is shown by the following table:—

Point Grey	7,300 acres	137,000 population
South Vancouver	4,800 acres	48,000 population
Burnaby	5,500 acres	65,000 population

At the present time the question of whether the combined or separate system will be the better for this area, is an indeterminable one. Under existing conditions, as previously stated, I estimate that the North Arm of the Fraser River can digest the sewage of 100,000 persons without nuisance or injury to fish life—provided proper dispersion is obtained. The time will undoubtedly come when either some form of local treatment will have to be adopted or an interceptor constructed. I have made provisions for the latter in the "Deferred Construction" estimates, and it is shown in a broken red line on Plan No. 10—although it is quite possible that future developments may make the former method more suitable. To meet the needs of the district during the next five years, I propose the construction of trunks on the lines shown on plans.

Estimates.

The following estimates of cost are set out under two heads, "Immediate Construction" and "Deferred Construction." The first covers all the work shown in firm red lines on the plan, and the cost of the trunk sewers constructed by the City of Vancouver (excepting the Maple Street sewer) and Point Grey, shown in green.

The sum of $200,000 is also included for the straightening and improving Still Creek and the Brunette River. It is proposed that these works should be constructed during the next five years. The expenditure being five and a half million dollars.

The "Deferred Construction" estimates give the cost of the construction that will be necessary to place the remaining area of the Peninsula on the same footing as the area covered by the "Immediate Construction" estimates, i.e., the provision of sanitary and surface water trunks for every area of 400 acres, together with such interceptors and outfalls as will be necessary.

These "Deferred Construction" estimates are of necessity of an approximate nature, and the amount of expenditure and the rate of construction required depends, of course, on the rate of growth and development of the Peninsula.

Estimates—Immediate Construction.
Area Draining to Imperial Street Outfall, English Bay.

(Coloured brown on Plan No. 10.)

Estimate of cost of construction of outfall, interceptor and sanitary and surface water trunks, as shown in firm red lines:—

Outfall	$175,000
Interceptor	662,000

TRUNKS (Sanitary and Surface):—

	Vancouver	Point Grey	South Vancouver	
Imperial Street area		$ 58,000		
Alma Road area	$ 18,000	101,000		
Balaclava Street area	372,000	398,000		
Bridge Street area	188,000	80,000	$74,000	
Totals	$578,000	$637,000	$74,000	$1,289,000
				$2,126,000
Outfalls to Trunks				45,000
				$2,171,000

NOTE.—The cost of the portion of Balaclava and Bridge Street trunks already constructed by the City of Vancouver is included in above estimates.

Area Draining to Clark Drive Outfall, Burrard Inlet.

(Coloured blue on Plan No. 10.)

Estimate of cost of construction of outfall, interceptor and combined trunks on natural area, and sanitary trunks on area draining naturally to Burnaby Lake, as shown in firm red lines:—

Outfall	$ 50,000
Interceptor	240,000

	Vancouver	South Vancouver	Burnaby	
Trunks (Combined)	$518,000	$137,000		
Trunks (Sanitary only)	95,000	56,000	$154,000	
Totals	$613,000	$193,000	$154,000	
Great Northern Cut Outfall				$960,000
				30,000
				$1,280,000

Area Draining to Burrard Inlet.

(Coloured pink on Plan No. 10.)

	Vancouver
Stanley Park Outfall:	
Outfall and Intercepter	$ 80,000
Hastings Park Outfall:	
Outfall and Trunk	40,000
Total	$120,000

Area Draining to Brunette River Outfall.

(Coloured yellow on Plan No. 10.)

Estimate of cost of construction of outfall and intercepter, as shown in firm red lines:—

	Burnaby
Outfall and Intercepter	$383,000
Still Creek, Burnaby Lake and Brunette River improvement	200,000
Total	$583,000

Area Draining to Fraser River.

(Coloured green on Plan No. 10.)

	Point Grey	South Vancouver	Burnaby	
Trunks and Outfalls	$96,000	$282,000	$420,000	
				$798,000

NOTE.—The cost of the Kaye Road trunk, already constructed by Point Grey, is included in the above estimates.

Abstract of Estimates.

Immediate Construction (During Next Five Years).

English Bay Area	$2,171,000
Clark Drive Area	1,280,000
Burrard Inlet Area	120,000
Brunette River Area	583,000
Fraser River Area	810,000
Total	$4,964,000
Add Engineering, Contingencies, etc.	536,000
	$5,500,000

Deferred Construction (During Following 25 Years).

Estimates of cost of providing trunks for the sewerage and surface water drainage of the areas shown part coloured on Plan No. 10, the surface water drainage of portion of Clark Drive area draining naturally to Burnaby Lake and the Fraser River interceptor:—

Burnaby Lake Area	$3,400,000
Point Grey Area	1,000,000
Fraser River Area	1,100,000
Total	$5,500,000

Construction and Control of Works.

It is unusual for the construction of works covering such a large area as these, and lying in several Municipalities, to be carried out under the immediate supervision of the Municipal Councils concerned. In cases where this has been attempted the results have not been satisfactory. Moreover, a work of this description should really be constructed without regard to Municipal boundaries. It should be looked upon as a scheme devised and carried out with a view to placing on a sure foundation the sanitary interests of the great city which will one day cover this Peninsula. Before putting before you proposals for the constitution and powers of a Joint Board, it will be well to outline for your information the constitution and powers of similar bodies which are doing excellent work in other parts of the Empire and the United States.

Melbourne.

The Melbourne and Metropolitan Board of Works received its constitution by Act of Parliament in December, 1890. The main object of the Board's creation was to provide Melbourne and suburbs with an efficient system of sewerage. The Board consists of a chairman and 39 members, who are nominated by 22 Municipalities and who hold office for three years, the representation being on a basis of assessment valuation. The salaried chairman, who must devote his whole time to the duties of the office, is appointed by the Board.

The Board has complete control of all sewer work within the Metropolitan area, and has, since its formation, spent over $30,000,000 on construction, which includes trunk sewers, branch sewers and house connections as far as the street line.

It has power to make and collect taxes on all property within its jurisdiction. The taxes are based on "net annual value," the maximum levy being one shilling and twopence in the pound on sewered property, and two pence in the pound on unsewered property. This corresponds, approximately, to a tax rate of seven and one mills to the dollar.

It is interesting to note that the Board is at the present time seeking further powers to control the Metropolitan rivers, streams and watercourses and sub-divisions of land.

Birmingham and District, England.

The Birmingham Tame & Rea Main Drainage Board was formed by provisional order of the Local Government Board in 1877, for the purpose of:—

> "(a) Purchasing such lands and erecting, making and maintaining such buildings, machinery and plant as may be required for the treatment at outfall works of the sewage of the several urban sanitary districts.
>
> "(b) Constructing or providing such intercepting sewerage works as may be necessary to convey the sewage of the several districts and contributory places to the said outfall works."

The constitution of the Board is similar to that of Melbourne, the members being elected by the constituent Municipal Councils from among the members of their own body for a term of three years. Neither the chairman nor members receive any salary.

The Board controls an area of over 90 square miles, with a population of nearly one million people.

The works and expenses incurred by the Joint Board and various Municipalities are divided into two classes:—

(a) "Outfall Works" include treatment works and all works necessary for conveying the sewage of any Municipality from that Municipality to its point of disposal, and all expenses of management. The cost of these works is defrayed out of a common fund contributed to by the various Municipalities in proportion to their respective populations.

(b) "Intercepting Works" include such works as may be necessary to convey the sewage of any district to the Outfall Works. These works, when serving one Municipality, **may** be constructed either by that Municipality or by the Joint Board, but where two Municipalities are concerned, the work **must** be done by the Joint Board.

The cost of any intercepting work is charged to such of the constituent authorities and in such proportion as the Board thinks fit.

Boston, Mass.

The Board of Metropolitan Sewerage Commissioners was established by Act of the Massachusetts Legislature in 1889. Its object was to provide for the building, maintenance and operation of a system of sewage disposal for the Myrtle and Charles River Valleys.

It is composed of three "able and discreet men, inhabitants of the Commonwealth," who are appointed triennially by the Governor with the advice and consent of the Council. Each member receives a salary of $3,000.00 a year. The Board has powers to construct and maintain certain defined works. The expenditure on sewerage works since the Board's formation amounts to about $15,000,000. The area controlled is now 199 square miles, lying in 24 Municipalities, and the population close on one million. To meet the expenses of the Board, the Commonwealth issues 40-year 4% bonds. The interest and sinking fund requirements are apportioned among the contributing Municipalities on a valuation basis, while the maintenance charges are on a population basis.

There are many other Joint Boards in operation; in England alone there are over 40, all working along similar lines to one of the three above mentioned.

Two very divergent views can be taken of the policy in which this scheme is entered upon; one, that it is a joint scheme in the sense that it is of common interest to every individual on the Peninsula, and the other, that the scheme is a joint scheme from the point of view of the Municipality rather than of the individual. To put it another way: the Peninsula can be considered as one large Municipality with common interest, or a group of Municipalities each with its individual interests.

Personally, I incline to the broader view; but I quite recognize that such a view is open to objection at the present time, as each Municipality has its own responsibilities and bond issues, and the interests of one may perhaps seem to clash with the interests of another.

I will now outline my views of what the constitution and powers of the Board should be, on the assumption that the Provincial Government will guarantee the bonds.

Representation.

A Board composed of representatives from the Councils of different Municipalities, with a chairman appointed by the Lieutenant-Governor in Council and holding office during his pleasure. The basis of representation would be roughly on population or valuation, and would give Vancouver two representatives and the outside Municipalities one each.

Assessment, Interest and Sinking Fund Charges.

to be assessed on one of the following principles:—

(a) The work to be divided into two classes: (1) that of common interest, which includes intercceptors, purification works, and all works designed for the prevention of pollution of natural bodies of water; (2) that of local interest, which includes trunk sewers draining 400 acres or over. The charges for (1) to be assessed over the whole district. The charges for (2) to be borne by the Municipalities in proportion to the assessment valuation of the area actually drained.

(b) The natural rights and liabilities of each Municipality to be taken into account. The charges for all works to be apportioned on a basis of the provision made for and the benefits derived by each Municipality. The apportionment to be fixed by the Board, with right of appeal to the courts from its decisions.

Duties.

The duties of the Board would be primarily to carry out and maintain the sewerage scheme as outlined in this report. They would also exercise a general supervision over all the sewer construction, and would take such steps as might be necessary to preserve the natural bodies of water from pollution.

They would have similar powers to a Municipality in the way of expropriating land, and would engage their own officers, and enter into contracts.

In concluding this report, I should like to remind the Committee that, although eighteen months have elapsed since this investigation was commenced, the time has barely sufficed for the collection of indispensable data. At the inception of the undertaking the plans of the district were incomplete and unreliable, and there was no information available as to the elevation of the greater part of the area. On my visit, a year ago, a considerable portion of my time was taken up in reluctantly designing and laying out in advance of the main scheme, portions of the Balaclava, Bridge and China Creek trunks. The success of a scheme of this description depends very largely on the selection of the points of outfall—a problem which involves extended and tedious float observations through the various different conditions of the tides, the wind, and the Fraser River.

Respectfully submitted,

R. S. LEA.

Per A. D. Creer.

REPORT

ON

BURRARD PENINSULA

JOINT SEWERAGE SCHEME

MADE TO THE

HON. W. J. BOWSER
ATTORNEY GENERAL, B. C.

MAY, 1913

BY

MR. C. H. RUST,
M. Am. Soc. C. E. & Can. Soc. C. E.

AND

MR. R. H. THOMSON,
M. Am. Soc. C. E. & Can. Soc. C. E.

Victoria, B. C.
May 13th, 1913.

Hon. W. J. Bowser,
Attorney General.

Sir:—

In accordance with your instructions, we have given careful consideration to the Act (Bill Number 105—1913), constituting the "Burrard Peninsula Joint Sewerage Board," and to Prof. Lea's report upon and his estimates of the probable cost of that portion thereof intended for immediate construction.

As we interpret the bill, its controlling points may be set out as follows:

Section 3: Authorizes the establishment of the "Burrard Peninsula Joint Sewerage Board" to consist of a chairman and one member from each municipality within the district, together with a clerk styled "Secretary-Treasurer."

Section 4: The chairman shall not be a member of the council of any interested municipality.

Section 11: That the Secretary-Treasurer shall be appointed—by the Lieutenant-Governor in Council, and must not be a member of the Board or of the Council of any interested municipality. It also authorizes the Board to engage all necessary solicitors, counsel, engineers, agents, etc., as it may deem to be necessary.

Section 13: Constitutes the Board a corporate body having perpetual succession and a common seal.

Section 14: Grants authority to enter upon lands, to make surveys, and to **construct, maintain** and **operate** sewers in substantial accordance with the report submitted to the Provincial Board of Health by the Joint Sewerage Committee, or in accordance with approved changes thereof.

Section 15: Authorizes the Board to take by purchase or otherwise, or to sell or exchange lands, water courses, rights, rights of way or easements; also any sewers, drains, culverts or portions thereof, heretofore built, which may be necessary for their work.

The procedure to expropriate is defined in said section 15 and the burden is placed upon the Board of making payment of all compensation, purchase price, and damages resulting by reason of such taking, (regardless of the fact that such right of way might in all propriety be necessary as a street or lane).

Section 17: Requires the Board to at all times indemnify and save harmless the several municipalities within which work may be prosecuted, against all damages which may be recovered by reason of anything done or omitted to be done by said Board, etc.

Section 18: Authorizes the Board to change the location of any water course, or the location or grade of any highway.

Sections 19 and 20: That the plans of all new sewers intended to be constructed by any of the municipalities within the sewerage district, must be submitted to said Board for its approval, and provides for penalties in case such plans are not so presented.

Section 21: Prescribes the amount of penalties to be inflicted upon persons destroying or injuring the property of the Board.

Section 22: Authorizes the Board to dispose of any unnecessary property.

Sections 24, 25, 26, 27 and 28: Authorizes the Board to enter into contracts for the execution of the work necessary to be done to construct such sewer systems, to take sureties for the completion thereof, and in general, to manage the same. These provisions do not require the contract to be awarded to the lowest bidder, and only makes mandatory **a three days' advertisement** of the proposed work.

Section 29: That the Board may, as soon as it receives the consent of the Lieutenant-Governor in Council, borrow the sum of $10,500,000 for a term not exceeding forty years, **provided** that the sum of $5,000,000 may be borrowed at as early a date as to the Board may seem proper, and the additional sum of $5,500,000 not sooner than three years after the passage of the Act, unless earlier authorized by the Lieutenant-Governor in Council.

Section 30: Provides that the securities issued to cover such loan shall not bear interest at a greater rate than four per cent. per annum.

Section 31: Provides for the establishment of sinking funds.

Section 33: Provides that "The Province of British Columbia may guarantee in the manner that may from time to time be prescribed by the Lieutenant-Governor in Council, **all of the interest upon said securities** and **the principal of said securities to the amount of $5,000,000,** when and as issued." It further provides that prior to the sale of such securities the Board may borrow money upon pledge or otherwise, upon such securities.

Section 35: That the Board annually certify to the various municipalities the amount of money which each must raise to meet its proportion of the annual expense of the Board and also its proportion of the sum required to provide the necessary sinking fund, and requires each municipality to properly levy for the same.

Section 38: That all salaries and other expenses incurred in the carrying out of the provisions of the Act, and that the preliminary expense heretofore incurred be paid out of the moneys of the Board.

Section 42: That this Act shall come into force on Proclamation.

The other provisions of the Act are partly advisory and partly directory as to the procedure of the various officers; the causation of and the filling of vacancies, etc.

From our reading of the Act, we understand that the Government may obligate itself if it so desires to do, to see that the interest upon the $10,500,000 is discharged and that the principal of said securities to the amount of $5,000,000 shall be repaid.

We understand that you desire from us a statement as to whether or not we deem the proposed sewerage scheme, referred to in Section 14 of said Act, as being feasible and practicable scheme, and as to whether or not, the various portions thereof may reasonably be executed within the limit of cost therein set out, and what further safeguards, if any, should be provided by the Government.

Upon the question as to whether or not the scheme is feasible and practicable, we would say: An examination of the report made by Prof. Lea shows that he has gone into the question of the proper sewerage of the various municipalities with great care, and has exercised great caution in the matter of polluting any of the waters whether fresh or salt, upon which any of the municipalities border, so that so far as the scheme is concerned, it is safe, feasible and practicable.

We believe that he has over-estimated the danger of polluting the various waters referred to and has therefore laid more stress than conditions justify upon the necessity and propriety of constructing the drainage system of that portion of the district discharging into English Bay, on what is known as the "separate

system," that is to say: by providing one series of conduits to carry off the sewage and another system of conduits to carry off the storm water. The plan proposes the separate system generally for all of the slope draining into English Bay. We believe this question to be worthy of further consideration. Nevertheless, if the plan of a separate system is adhered to, the proposal as it now exists is both practicable and feasible.

Owing to the lack of topography, and to the very undeveloped character of the land, his study of the Burnaby territory is very incomplete. Much more time and labor will have to be put upon this portion of the district. In fact, so far as Burnaby is concerned, the report is merely a preliminary suggestion, subject to great modification and revision. Nothing else was possible with the data in hand when the report was prepared.

As to the question whether or not the various portions thereof may be reasonably executed, within the limit of cost therein set out, we would say: That whilst the bill contemplates the final expenditure of ten and one-half millions of dollars, the scheme, so far as it has been outlined, has only been so far outlined as to cover work estimated by Prof. Lea to cost five and one-half million dollars, and estimated by Mr. Thomson to cost $5,822,000, exclusive of the discount on debentures, the acquisition of rights of way and accidental contingencies. The use for and lines of expenditure upon which the remainder of the sum is to be made, is, so far, undecided or unknown. Neither the estimate of Prof. Lea or that of Mr. Thomson upon the portion which has been partially outlined, can be considered as conclusive, from the following facts:

(a) The Lea report is purely preliminary.

(b) Being preliminary, there had not been prepared before its presentation the full detail plans of any of the proposed sewers nor had there been fully determined the exact nature of many of the details which might materially affect the cost of construction.

(c) The location of several of the larger trunk sewers, as set out in the reports, is tentative and a change of location, based upon further study, would probably materially lessen their cost, or, on the other hand, might possibly slightly increase the same.

(d) Measuring upon the map with reasonable accuracy, we find that there will be something more than sixteen miles of right of way to be acquired across private property. As suggested elsewhere, doubtless much of this right of way should be obtained

as street or highway. In any case, it should all, so far as possible, be acquired prior to the next sitting of the legislature, so that if any material increase in the total estimate of cost of these sewers be necessary, the amount thereof may be included in the authorization made in the new bill. It seems to us that where possible all sewers ought to be placed along or near the center line of highways, but if the nature of the land is not such as to justify a highway, that at least lanes, twenty feet in width, should be opened by the municipalities to receive the sewers. The cover under which these sewers are expected to be placed across much of this private right of way, i very light, making it the more difficult to claim that they will not be liable to objection from the owner of the land. We regard this as a serious matter, and until the cost of these rights of way are known, the final cost cannot be properly estimated.

(e) There is a great uncertainty as to what charges the municipalities will have to bear in the matter of the disposal of the storm waters from the China Creek district. There is, in the franchise granted to the Canadian Northern Pacific Railway, a sentence which appears to relieve the district of any responsibility with reference to these sewers. The actual meaning of that sentence ought to be fully agreed upon before undertaking this work.

(f) Owing to the low rate of interest provided to be borne by these debentures (four per cent.) we are assured by the Chairman of the Joint Committee, Mr. Walter Hepburn, that any debenture sold at the present time will not realize more than eighty-five per cent. If five and one-half million dollars face value of these debentures should be marketed at eighty-five per cent., they would net the municipality but $4,675,000. This would occasion a prima facie shortage of $825,000; or, under Mr. Thomson's estimate, a prima facie shortage of $1,147,000, in each case exclusive of the unknown costs of rights of way and other incidental expenditures.

Referring to clause 29 of the Act, by which the Board is empowered to borrow an amount not exceeding $10,500,000 for a term not exceeding forty years, only five millions of which may be used within the first three years, we would draw your attention to the fact that the report as submitted, calls for an expenditure of $11,000,000 of which $5,500,000 was to be spent within the first five years. A shortage of $500,000 in the estimated fund has therefore, already been made by reason of the difference of the amounts set forth in the Act and in the estimates. If therefore, for

working purposes, five millions must be taken as a basis, eighty five per cent. of the same would be but $4,250,000 and the shortages would amount to $1,325,000 and $1,647,000 respectively in addition to the costs to be incurred for right of way and any other incidental matters.

After most careful consideration, we do not believe that there is sufficient data at hand to justify the Board in being permitted to undertake the scheme in its entirety. We recognize, however, that relief should be provided certain sections of the district and to that end that immediate construction ought to be undertaken upon two or three extensions of existing sewers which fall within the plan. We suggest the following course of procedure as being one which would be worthy of consideration in furthering this matter:

1st. That the Act be proclaimed at an early date and the Board constituted as soon thereafter as convenient.

2nd. That the Board, when constituted, be permitted to secure from the bank a loan of $50,000 for the completion of detail plans of the scheme, and that, in particular, they be authorized to lay before the Government full, complete and definite plans and specifications and estimates for the construction of the following sewers, which, in the interest of public health, are urgently required, to-wit:

a. The extension of the so-called Canoe Creek through D. L. 301 to the boundary of South Vancouver.

b. The extension of the China Creek sewer southerly to Porter street.

3rd. That upon the presentation to and approval by the Government of the plans, specifications and estimates for such sewers the Government consent to authorize and guarantee, as provided in the Act, such debentures as it may be necessary to issue to cover the estimated cost of the construction of said sewers, together with any sum which justice demands should be repaid on account of advances made.

4th. That the Board be advised by the Government to use proper means to obtain, prior to the next sitting of the legislature, all necessary rights of way and easements, and, so far as possible, to induce the various municipalities through which the sewers are to be carried, to acquire at their own cost and expense, such of the necessary rights of way as will be of such width as to be serviceable as highways or lanes.

5th. That other than the prosecution of work upon these urgently needed sewers, and the completion of detailed plans, specifications and estimates for the remainder thereof, and provisions for reimbursement as mentioned, that no further indebtedness be authorized by the Government during this year.

6th. That at the next session of the legislature, the Board be authorized to present to the Government, a perfected scheme for the work, together with its revised estimates, including costs of rights of way, whereupon, an amended Act should be passed, confirming such scheme and authorizing such expenditures for the construction thereof as the completed report may indicate, and fixing a rate of interest which will reasonably guarantee the sale of the debentures at par.

We believe the principal necessary safeguards have been indicated above, but we further recommend that instead of an advertisement of but three days being mandatory, that the period through which advertisement should run for any work estimated at less than $100,000, be for a period of not less than ten days, and that the period required for the larger undertakings, be not less than twenty-one days.

Herewith returned copy of Lea report, accompanied by book containing tabular statement of Mr. Thomson's estimates.

Respectfully submitted,

(Sgd.) C. H. RUST

(Sgd.) R. H. THOMSON.

SUPPLEMENTARY REPORT

MADE BY

R. S. LEA

To the Chairman and Members

OF THE

VANCOUVER AND DISTRICT JOINT SEWERAGE AND DRAINAGE BOARD

February 14th, 1917.

GENTLEMEN:--

Some time ago I received a request from you through your Secretary, Mr. George W. Phipps, to look over and report upon the work carried out by the Board, and to advise with regard to future procedure and operations.

In complying with this request, I have kept in mind, as suggested, the provisions of the Act for the carrying out by the Board of the work under its charge "in substantial accordance" with my report to the Burrard Peninsular Joint Sewerage Committee in February, 1913.

The Act referred to is "An Act Providing for a Joint Sewerage and Drainage System for the City of Vancouver and adjoining Districts," entitled the "Vancouver and Districts Joint Sewerage and Drainage Act, 1914, and Amending Act, 1915."

The report referred to is a report made by the undersigned to the special committee, composed of representatives of Vancouver, Point Grey, South Vancouver and Burnaby, which was formed early in 1911 for the purpose of procuring a general plan and report upon a joint sewerage and drainage project which would provide for the whole territory included within the boundaries of these municipalities.

In the following pages they will be referred to, respectively, as "The Act" and "The Report."

INSPECTION.

In accordance with the terms of the communication referred to above, and further verbal instructions, I have made a general inspection of the works completed by the Board since its formation. In this inspection was included observation in service of portions of the Balaclava and China Creek Trunk Sewers, constructed in 1912. These sewers were built and paid for by the City of Vancouver in anticipation of the ultimate approval and adoption of the scheme and their incorporation therein. They have since been taken over by the Board.

I have also revisited and examined a number of points in the District where the conditions are of controlling interest and importance, as affording information which requires the most careful consideration in the planning of the details of the system if the objects aimed at in the project as a whole are to be fully attained.

I have taken note of certain new and valuable rainfall records which have become available since the original scheme was presented, and in a general way have looked into the conditions and circumstances affecting the past and future operations of the Board.

Provisions of the Act.

Mention has also been made of certain provisions in the Act for the carrying out of the main sewerage project as embodied in the Report. The reference was made particularly to Clause 14, which reads as follows:

> "The Board shall have power within the sewerage district, and without such district with the consent of the Lieutenant-Governor in Council, at any time to enter upon any lands, without the consent of the owner thereof, and to make all necessary surveys, and to construct, maintain, and operate such main sewers, sewers, and drains, and other works in connection therewith as shall, in the opinion of the Board, be required for a system of sewerage and sewage disposal and surface-water drainage within the sewerage district, in substantial accordance with the report bearing date the first day of February, 1913, made by R. S. Lea, Esquire, consulting engineer, and submitted by the Burrard Peninsula Joint Sewerage Committee to the Provincial Board of Health, and filed in the office of the Provincial Secretary, or in accordance with any changes in such system that may be made by the Board with the approval of the Lieutenant-Governor in Council; and for the above purposes the Board may enter into contracts with any person for the construction, maintenance, and operation of the works aforesaid or any part thereof, or may execute such works or any part thereof without contract, and for such purpose may purchase materials and employ labour as may be required."

Briefly, it is the intention and purpose of the entire Act to effectively provide for the carrying out of the project in accordance with the single comprehensive and uniform design, as described in the Report approved and adopted by the municipalities and subsequently by the Provincial Government itself. Certain customary qualifying phrases are inserted in Clause 14, which provide the Board with the necessary legal safeguards in the unhampered performance of its duties, and which are especially advisable in connection with a work much of which will not be constructed for many years to come.

In making further comments upon the work already carried out by the Board, and in submitting advice as to its future course of action, I shall do so with particular reference to the provisions of the Act which have just been discussed, as well as to the purpose of the original Committee and of the Engineer in preparing the Report and in carrying out the eighteen months' series of observations and experiments upon which it was based. In doing so it will be of advantage as well as convenient to recall the circumstances attending the inception of the scheme and the development of the general plan for carrying it into effect.

The growth in population of Vancouver had for several years been so rapid that by 1910 and 1911 there were large areas of the city, particularly on the southerly side of False Creek and adjoining English Bay, without any sewerage facilities whatever, and where the need for adequate provision for both sewerage and drainage was becoming increasingly urgent.

A similar state of affairs existed in the adjacent municipalities, where streets were being opened up and building operations extended in every direction and in all parts of the Peninsula reached by the B. C. Electric Railway Company.

The situation of this newer part of Vancouver, surrounded as it was by the higher lands of the other municipalities, was in itself an indication that some kind of co-operative action would be necessary. Consequently, after some public discussion, a joint committee with Mr. H. H. Stevens as first chairman was appointed in April, 1911, to deal with the question of "a general scheme for the entire district."

The writer was engaged by the committee as consulting engineer and made his first visit to Vancouver in that connection in the following June.

General Outline of Proposed Scheme.

After some days spent in a general survey of the situation, it became evident that the scheme contemplated would cover the entire Burrard Peninsula from the Western extremity of Point Grey Easterly, to include the Still Creek and Burnaby Lake Basin. All indications pointed to the necessity of providing not only for the sewage proper, but for the surface and storm water as well, in which respect it would differ from all other joint sewerage propositions, which consist only of outfall works and intercepting sewers designed to deal with little more than the dry weather flow of sewage.

It also appeared advisable to plan a system on such a comprehensive scale as to be capable of extension at any time within the limits stated, and such that all construction, whether in the immediate or distant future and in whatever part of the district it might be required, would conform to one general plan and be carried out according to one uniform design.

The unusually favorable topographical features of nearly the whole of the district, together with the proximity on all sides of the large bodies of salt water, encouraged the expectation that such a scheme with all its concomitant advantages, could be carried out at a low cost, when compared with other undertakings of the kind elsewhere; and that it would prove truly economical from the first, in view of increase in population, which there was every reason to anticipate.

To achieve this result it would be necessary to take the fullest advantage, in the general plan and subsequent detailed design, of the exceptional conditions referred to. It was also recognized that to secure the necessary data for such an undertaking would require much time and the expenditure of a considerable sum of money. The committee approved of the idea and agreed to provide for the expense which would be entailed. It had, indeed, already anticipated this action to a certain extent, by arranging with each municipality to furnish contour maps covering its particular area.

It was further realized that assistance would probably be required from the Provincial Government in the raising of loans to meet the cost of construction, which would be in line with the precedent furnished by the Metropolitan Sewerage District of Boston and adjoining municipalities, where the State itself issues the bonds and charges the interest and sinking fund to the municipalities.

It was accordingly arranged to proceed at once with the necessary surveys and investigations, and to prepare, as soon as feasible, a report upon the definite scheme along the lines referred to above, to be accompanied by a general plan and estimates of cost sufficiently close to indicate with reasonable accuracy the dimensions of the sum for which it would ultimately be necessary to make provision. The working out and elaboration of the plan in detail would at this stage have been unnecessary and an expensive proceeding, and would, according to universal custom, follow in natural sequence the adoption of the Report and the completion of the necessary financial and other arrangements for proceeding with the undertaking.

Investigations.

Many of the local and regional conditions were quite unusual and definite information concerning them was in large part lacking. The same was true regarding information which is usually available on demand under similar circumstances in older communities, such as reliable plans, levels, records of rainfall and runoff, etc., the last of which was of special importance in this particular scheme because it was to include a complete system of trunk sewers of sufficient capacity to deal with all surface water, in addition to the interceptors and their outfalls for domestic sewage, to the provision of which other joint schemes are limited.

The great area of the district, between 80 and 90 square miles, or five times that of Greater Montreal, the range in elevation and variety in surface conditions, the extent of the shore line and of the boundary waters, the complexity and variability of the currents, the singular tidal phenomena of the short-and-long tide, all combined to present a number of unusual and important problems and to indicate that the working out of a comprehensive scheme would be a considerable undertaking.

Rainfall Records.

The intensity of the heaviest rainfalls during short periods is one of the most important factors in determining the capacity of storm water sewers. Automatic rain gauges which give a continuous graphical record of the amount and rate of the rainfall are required for this. One of these had been installed about this time by the City of New Westminster, and the B. C. Electric Company had two or three in operation in connection with their hydro-electric developments for a couple of years or so previously; but

the nearest point where such records had been kept for any considerable time was at Seattle, Wash., where a twelve year series was available. Automatic gauges were set up at two points in the sewerage district and read in conjunction with the New Westminster and B. C. Electric gauges. These records were compared and studied in connection with records of the Government Meteorological Stations at selected points along the coast of British Columbia and adjoining states of Washington and Oregon. By such means it was possible, with prudent allowances, to interpret and apply the Seattle records to the Joint Sewerage problem. A rainfall and runoff diagram was thus developed for use in design which it is satisfactory to learn has so far proved adequate.

Hydrographic Work.

A careful and comprehensive study of the tides and currents was undertaken in connection with the location of the outfalls for the interceptors. The latter are the large sewers which in general parallel the shore line, cross the large collectors and trunks and receive or intercept the domestic or dry-weather sewage only. As stated previously, these sewers alone with their outfalls or other disposal facilities comprise the entire works in other joint sewerage undertakings. Although in the present project they form only the smaller part, from the constructural point of view, their functions and effectiveness with which they perform them constitute the all important features of the scheme from an aesthetic and hygienic standpoint, and in many other ways as well. It was a matter of paramount importance that these outfalls should be fixed, definitely and permanently, inasmuch as by doing so the foundation upon which the whole structure of the design is based would be correctly established once for all. This meant investigating each prospective location, taking into consideration the quantities of sewage which would be discharged at each point, not only in the next 10 or 15 years, but when the whole tributary area would be built up.

This work was therefore carried on with care and as thoroughly as possible. Automatic tide gauges were established in English Bay and Burrard Inlet. A large number of observations were made with spar floats, arranged so as to be only slightly affected by the wind, and of different depths to indicate differences in currents at the surface and at greater depths. These floats were set out from certain fixed points off Point Grey and the south shore of English Bay, and in Burrard Inlet from the First to the Second

Narrows. Their paths were followed by motor boat, and located by sextant observations on shore stations. They were set free at all stages of the tide—ebb and flow—and during the 12 to 15 hour period of practically slack high tide, which in the Gulf of Georgia, occurs for a certain number of days every month. During this period the tidal currents are comparatively weak and uncertain. Around the Western shore of the Peninsula and in English Bay they are strongly affected by the discharge of the Fraser River, which at all times exerts a very important influence. The float observations not only covered all stages and ranges of tide from spring tide to spring tide, at each location, but as they were carried on for over a year they included the annual tidal variation which is characteristic of Pacific Coast waters.

It may be stated here that the tidal phenomena alluded to above added considerably to the difficulty and length of time required in these investigations.

The period also covered all stages during a full year of the Fraser River, and in view of its dominating influence around Point Grey and in the Southerly half of English Bay, particular attention was devoted to studying and observing the effects of its discharge. At its extreme minimum this amounts to 20,000 sec. ft., while at high water it has been as high as 400,000 second ft. The huge quantity of fresh water which this River is continually discharging tends, of course, to greatly diminish the saltness of the water in this part of the Gulf. Advantage was taken of this fact to determine more closely still the manner in which the Fraser River influences the currents around the shores of the Burrard Peninsula. By the use of the salinometer, an instrument which enables the percentage of land and sea water in any sample to be readily determined, the direction and extent of the flow of the fresh river water was easily traced as it spreads over the top of the heavier salt water of the advancing and receding tidal flow.

The variations of the proportions at different depths during the ebb gave a measure of the mixing which takes place every tide as well as much other information which added materially to the value of the float observations.

This work was carried on without interruption to the end of 1912.

Advance Construction.

The demands for sewerage from certain localities in the Kitsilano and China Creek areas had been so insistent during the summer of 1911, that the Vancouver authorities expressed their willingness to construct the necessary sections of the Balaclava and China Creek trunk sewers during the season of 1912 at their own expense and of the capacity necessary to form part of the joint scheme, if plans for the same could be supplied by the writer so far in advance. Under the circumstances this request was reluctantly acceded to on the understanding that only such portions as were absolutely necessary would be constructed, and that temporary arrangements would be made at each outfall so that the permanent work would stop at such points and at such elevations as would admit of their extension and connection with the interceptors in accordance with the detailed plans to be finally adopted.

Accordingly plans were prepared. The capacities were determined by making liberal allowances for lack of data. A horse shoe section was adopted, consisting of arch, sidewalls and invert of the form employed in the large sewers of the St. Louis Main Drainage. The designs were made with care, and called for the use of reinforced concrete, the invert to be lined with the highest grade of hard paving brick.

Before the matter had been finally decided, an endeavor was made to obtain from the Provincial Government its immediate assent to the joint proposition, assurance of its financial support and the passage of the necessary legislation to enable a Board to be created to proceed with the undertaking. This would enable detailed plans of the whole project, the expense of which is properly a part of the construction cost, to begin at once.

A general outline of the scheme with an approximate estimate of inclusive cost and suggested methods of administration, etc., was submitted for consideration. The Government decided, however, to defer any action until the general plan and report had been completed.

This was pushed ahead with as little delay as possible under the immediate direction of Mr. A. D. Creer, M. Can. Soc. C. E., who was appointed as Resident Engineer, about that time.

Meanwhile contracts were let by Vancouver for the Balaclava and China Creek trunk sewers, and construction was practically completed by the end of 1912.

The Final Report.

The committee was kept posted with respect to the investigations by progress reports submitted from time to time. These investigations were continued practically up to the date of the submission of the final Report in February, 1913.

It was intended and would have been more satisfactory to have included as an appendix to the Report, tabulated records of the data collected during the investigations. Much of this was of general technical and scientific interest, apart from its value for future reference. There was, however, no time available for its arrangement and classification, as the Committee was naturally anxious to have the scheme submitted to the Government in the approaching session.

The general results of the investigations upon which the recommendations of the Report had been based were presented in graphical form in a number of appended diagrams.

These included a diagram showing the rate of growth of certain cities after they had reached a population of 180,000, which was the estimated population of the Peninsula at that time. From this and other relevant data a curve of growth was projected for the population of the Peninsula. This curve is necessarily a forecast of the average growth; that is to say, it will represent the actual conditions of growth the more closely, the longer the interval of time considered. This is because of the inevitable recurrence of periods of accelerated growth after periods of depression, which characterizes the history of all large cities.

The whole work contemplated under the joint scheme was divided into two parts for estimating purposes. Under "IMMEDIATE CONSTRUCTION" was included the cost of the sewers and necessary outfalls for those districts, which, on the basis of the estimated growth in population, would require sewerage facilities within the next five years or by the end of 1917. Under "DEFERRED CONSTRUCTION" was included all works necessary for the completion of the joint scheme, the cost of which would be spread over an extended period of years, depending upon the rate at which the population would continue to increase. The estimate in each case was $5,500,000, making a total of $11,000,000 for the whole project.

This estimate, though amounting to a considerable sum, is small when viewed in the light of the cost of such other undertak-

ings as afford a basis of comparison, and also in view of the facilities provided.

First: The area dealt with is very large, totalling about 83 square miles. It is therefore in this respect one of the largest joint schemes in the world

Second: Practically every other joint scheme provides only for the dry-weather-flow intercepting sewers, with their necessary outfalls or disposal works; whereas, in this case, all storm water is taken care of as well. The capacity required for the latter purpose is often 30 to 40 times that required for domestic sewage alone.

Third: In other such schemes the joint sewers are only required to extend to the boundary of any particular municipality, within which all sewers of every description are provided by the municipality itself. For example, in the Metropolitan system of Greater Boston, the areas of these different municipalities average from 6,000 to 7,000 acres. In the Vancouver and Districts system all trunks are constructed by the Board as part of the joint scheme, up to a point where they will serve an area not greater than 400 acres. This scheme, therefore, in addition to providing for all joint requirements, in effect provides a main drainage system for each municipality within its own borders, which ordinarily would be constructed at its own separate cost.

Beside the exceptional character of the facilities afforded by the proposed project, there are certain other advantages incidental to the circumstances under which the scheme was inaugurated.

In most large cities, the sewerage system is for years carried out in a more or less piecemeal and haphazard fashion, and in accordance with no definite or uniform method of design. Main drainage schemes, when the necessity for them arises, must be adapted to the conditions as they have developed, with a consequent loss in economy or efficiency or both. In the system proposed, there was no such handicap. Throughout the greater part of the territory, owing to the recent rapid development, even street sewers were in most cases lacking. Hence was afforded the unique opportunity of projecting an entire new system in accordance with a uniform plan of development, which, by reason of the favorable local conditions and the definite limits set to the drainage areas by the height of land, could be economically designed to provide for practically any probable future growth. The manifest advantages of such a system requiring no further alteration or duplication, need not be enumerated.

After the completion of the Report in February, 1913, and its approval by the Provincial Board of Health, it was submitted by the Joint Committee to the Provincial Government, which accepted the scheme as presented and promised its financial support in the way of a guarantee of bonds. Before the end of the session, an Act was prepared for the purpose of carrying it into effect, and which also provided for the creation of a permanent Board to take the place of the original Committee.

Rust and Thomson Report.

As a final measure of precaution, the Report and the draft of the Act were referred to two consulting engineers, Messrs. Rust and Thomson, for their opinion. They reported in May, 1913, that so far as the scheme itself was concerned, it was "safe, feasible and practicable," and recommended "That the Act be proclaimed at an early date and the Board constituted as soon thereafter as convenient." They advised that the Board be permitted to secure from the bank a loan of $50,000 for the completion of detailed surveys and plans for the whole scheme. They further advised that the Board be empowered to proceed with two urgently needed extensions to the work, which the city had already constructed in the China Creek area, the Government to authorize the necessary debentures to cover the cost of these sewers and the expenses incurred by the Committee in connection with the preliminary investigations and report.

In conclusion, they recommended that no further construction should be undertaken until the completion of a detailed plan, and that final action regarding the guarantee of securities be deferred until the following session.

Inauguration of Joint Board.

The present Board was inaugurated in August, 1913, and at once proceeded in a general way along the lines suggested by Messrs. Rust and Thomson, except that their advice with respect to the early completion of a detailed plan of the entire scheme was not followed.

Early in 1914, the Government guaranteed the Board securities to the extent of $5,000,000 and in May an issue was made of 500,000 pounds at 96, which netted something less than 92½, after underwriting and other expenses had been deducted.

Mr. Creer, who had been Resident Engineer, was retained as Engineer to the Board and construction has since been carried on without interruption on the proceeds of the 500,000 pounds issue.

The Work Completed.

The completed portion of the joint scheme includes.

(a) The work which has been carried out under the direction of the present Board.

(b) The sections of trunk sewers constructed by the City of Vancouver in 1912.

(c) Certain other sewers which had been built by the City and by Point Grey, before the joint scheme was undertaken, but which have since been taken over by the Board and incorporated in its work.

It will be referred to only in a general way, as a detailed description would be quite beyond the compass of this report, but would properly form part of a future report of the Board which is referred to further on.

Balaclava Area.

The City of Vancouver had constructed the trunk sewer in this area from Point Grey Road to Ninth Avenue in 1912, as part of the joint scheme. It is of reinforced concrete, a horse shoe section, ten feet four inches wide by eight feet three inches high. The invert is lined with the highest grade paving brick.

The Board has acquired this section at a cost of $94,830.36. It discharges through a temporary outlet consisting of four wood stave pipes. This will permit the construction of a screen chamber and regulator connection with the future English Bay intereeptor after the final plans of the latter have been completed.

The Board has extended this sewer on Balaclava Street from Ninth Avenue to Sixteenth Avenue, and has constructed a branch on Ninth and Tenth Avenues to Vine Street, at a cost of about $152,650.

Bridge Street Area.

The Board has constructed no sewers in this area so far, but has purchased from the City of Vancouver the trunk sewer in Bridge Street, built in 1912, with an outlet at Sixth Avenue and Heather Street, for the sum of $110,401.98.

It has also arranged with the City:

"To request the Lieutenant-Governor in Council for permission to revise the Joint Scheme to include the undermentioned sewers in the Joint Scheme. And that they be purchased by the Board with funds to be provided in the next bond issue."

Tenth & Bridge to Sixteenth & Ontario,	$33,500.00
Sixteenth & Willow to Twelfth & Bridge,	45,595.56
Dufferin & Yukon to Bridge & Sixth,	14,582.56
Total,	$93,678.12

China Creek Area.

The main trunk sewer serving this area which starts at Seventh Avenue and Keith Drive was constructed as far as Eleventh Avenue in 1912 by the City of Vancouver, as a part of the proposed joint scheme. This is the largest sewer of the entire system; and this section of it together with the Balaclava trunk sewer, was previously referred to as having been designed by the writer early in 1912. It is eleven feet four inches wide and nine feet one inch high. It was purchased by the Board for the sum of $83,028.13, which sum included the cost of a short branch up China Creek from Eleventh Avenue to Twelfth Avenue, which was built under the same contract. Another sewer which now serves as an extension of this branch, and which had been built by the City in 1910,1911 and 1912, has also been purchased by the Board for the sum of $15,000.

The first work of the Board was:

(a) The continuation of this branch to 25th Street and George Street, and 25th Street and Glen Drive,

and

(b) An extension of the China Creek sewer from Eleventh Avenue to Fourteenth Street, with a branch from Fourteenth Street to Nineteenth Avenue, at a total cost in round figures of $233,000.

These were the sewers referred to by Messrs. Rust and Thomson as being urgently required.

Since then the Board has continued the construction of the China Creek system of trunk sewers and branches as far as Central Park, at an additional cost of $332,000. This practically completes the joint sewers for this entire drainage area, extending almost to Royal Oak, with the exception of the storm water sewers of a portion at the upper end, which is sewered on the separate system.

A considerable part of this work has been constructed in tunnel, and certain changes have been made in the location, as given in the Report, where detailed studies and further surveys have shown them to be desirable.

Clark Drive Interceptor and Outfall.

From the lower end of the China Creek Sewer at Keith Drive and Seventh Avenue, an intercepting sewer has been built to Burrard Inlet by way of Clark Drive. It discharges at the bottom of the harbour through an outfall tunnel extending from a shaft near the shore to a point well beyond the pier head line.

At the head of this interceptor a separating chamber has been built by means of which any desired proportion of the discharge of the China Creek sewer during storms may be diverted by an overflow into the head of False Creek.

This work was constructed during 1915 and 1916 at a total cost of about $304,500.

Hastings Park.

The trunk sewers constructed for this area discharge into Burrard Inlet at Cassiar Street, but the outfall will ultimately be extended to the Second Narrows. They are largely in tunnel and at a sufficient depth to intercept a considerable area which would naturally drain towards Still Creek. Nearly half of the territory served is in Burnaby and is greatly in excess of the area contemplated in the Report. The cost of this work was about $265,000.

Brunette River.

About $41,500 has been spent in lowering the bed of the Brunette River for a distance of about a mile below the outlet of Burnaby Lake, and in the construction of a control dam. No further work should be done here until a detailed study of the whole valley has been made as outlined further on.

West End Interceptor.

This work was only started in November of last year and is in progress at the present time. It is to discharge through a tunnel outfall into the bottom of the channel off Brockton Point, and will extend from there, partly in tunnel, under Stanley Park, across the Coal Harbour Causeway, with one branch through a tunnel to Beach Avenue, and another up Georgia Street. It will provide for the sewage of the West End, which at present discharges into the harbor between the Causeway and Burrard Street, on the one side, and into English Bay and False Creek on the other.

The amount expended on this work to December 31st, 1916, was a little over $11,000.

This briefly outlines the extent of the work so far included in the Joint Sewerage Scheme. The area served directly is between nine and ten thousand acres, or in the vicinity of 15 square miles. This is a pretty extensive area in itself and is only exceeded by that of the larger cities. For instance, it is about two-thirds of the present area of Manchester, England, and is nearly twice the size of the Montreal of twelve or fifteen years ago. As it is the lower and larger sections of the trunk sewers which are built first, it represents a larger proportion of the whole work than is indicated by the area.

Method of Construction.

Some of the work of the Board has been done by contract, but the greater part has been carried out by day labor. With one or two exceptions, notably Hastings Park, the cost has apparently not been greater than by the contract method.

Quality of the Work.

I have inspected the interior of several of the sewers built by the Board and have re-examined the Balaclava and China Creek sewers built in 1912, partly for purposes of comparison. So far as one can judge by the appearance of the completed work, it is first-class in every respect; and, particularly in regard to the invert work, it is an improvement upon the high quality of that obtained in connection with the trunk sewers just referred to. It is seldom on a work of this magnitude that there is so little open to criticism. As a matter of fact, in addition to my own experience, I have at different times had opportunities of observing a good deal of work of this kind, including several of the largest projects, both in Europe and in the United States, and as a result, I believe I may fairly state that the sewers so far constructed for the Vancouver and Districts Joint Scheme are superior to those of the great majority of cities anywhere in the world and are excelled by none.

This must be a matter of gratification to the Board and reflects great credit on the Engineer and his staff.

Cost of the Work.

The cost of the work to date cannot at this stage be readily compared with the estimates presented in the Report. Mr. Creer has, however, worked out a comparison on a unit basis, and according to these figures the costs are in general well within the original estimates.

The Board's Construction Programme.

The "IMMEDIATE CONSTRUCTION" estimates of the Board contemplated the expenditure of $5,000,000 within five years. But this programme was based on a continuance of the rapid increase in the population, which would have in that time reached a figure considerably over 250,000. Instead of this I understand that, if anything, an actual decrease has taken place. In view of this fact the expediency of the extensive construction which the Board has carried out would appear somewhat doubtful. With the exception of the Canoe Creek Branch and the first extension to the China Creek sewer, practically no part of the Board's work in the China Creek area has so far been utilized. The same, I understand, is true of the Balaclava extensions and the Hastings Park work.

There is some advantage of course in having drainage facilities available when the conditions again become normal and the growth of population is resumed. This whole matter is perhaps largely a question of policy which is the particular concern of the municipalities. At any rate, there does not appear to be any immediate necessity for further construction on an extended scale.

One decided objection from an engineering point of view, to which I must refer, is the prosecution of the undertaking to such an extent before the detailed survey and plan of the work as a whole has been completed.

Messrs. Rust and Thomson, in their Report, advised that none but the most urgent work should be undertaken until this plan had been made, recommending that it be proceeded with without delay, and that the sum of $50,000 should be appropriated for the purpose. The matter was not specifically referred to in the original Report because it is a procedure which goes without saying. The expense, including borings, soundings, etc., would be considerably less than one per cent. of the cost of the project. The difference between two close bids is usually much greater than this. In any case there can be no question of the wisdom of this expenditure, as a business proposition. It will undoubtedly be recovered many times over in the economies thereby made possible in the ultimate construction of the work.

However, there is a compensating advantage in the delay in making this plan, inasmuch as there are now available four additional years of rainfall observations. The value of such records is in general proportional to the length of the period covered. This advantage has, by good luck, been considerably enhanced.

Within the last four years two phenomenal storms have occurred, the like of which may not take place again for thirty years; one was of the "cloudburst" variety, which is extremely rare on the Pacific slope, and the other was a 48-hour continuous downpour on frozen ground, and with other conditions favorable to a heavy runoff. The records of these storms have confirmed the general reliability of the original runoff diagram and will enable future capacity calculations to be made with greater confidence.

Future Procedure.

The first matter that should receive attention is the work connected with the detailed plan of the whole scheme, referred to above. This should give way to nothing else.

The West End Interceptor which is now under construction should of course be completed, but no other work of any extent is required in the near future.

As has been stated, comparatively little use has so far been made by the municipalities of the trunk sewer which has been constructed by the Board. There are, however, several places, particularly in the China Creek area, where storm water can be turned into them by a temporary arrangement until such time as the local connecting sewers are in place. The sewers should be provided with wooden catch basins and rough screens, and should be made of sufficient capacity to take all the surface water which would naturally flow to these points.

Surveys

Considerable work has already been done by the engineers of the Board upon the surveys, etc., which are required for making the detailed plan. This includes a triangulation survey of the whole Sewerage District, the establishment of permanent bench marks, contour surveys, principally in the Burnaby Lake area, and the plotting of accurate plans to large and small scales.

Beside its use for the special purposes of the Board, this work when completed will be of the utmost value to the District in various other ways. It was, however, discontinued at the end of the year 1915, and has not since been taken up. It is hardly necessary for me to say that it should be resumed at once, and completed with as little delay as possible.

Burnaby Lake Basin.

There are certain points in connection with the detailed plan that I wish to make special reference to. The first is the Still Creek —Burnaby Lake—Brunette River Valley. The water course itself, from where it starts in Hastings Townsite to where the Brunette River enters the Fraser, is about ten miles in length. The total fall is slight, and occurs largely between Burnaby Lake and the Fraser River. Still Creek is consequently an extremely sluggish stream, flowing through flat, swampy bottom land. The drainage area tributary to it is large, and as it becomes cleared and improved, it will shed storm water at a continually increasing rate. The creek will require to be straightened and otherwise improved to carry these flood waters. This will necessitate determining, once for all, the way in which Burnaby Lake is to be dealt with, the ordinary level at which it is to be maintained, the improvement required at the mouth of the Brunette River, which is outside the District, and in what authority the control of the waters is at present vested. It is out of the question to carry sewage down this open waterway, and hence the separate system of sewerage is imperative for the whole basin. So far, the population is small, but building has already been carried on to some extent along the upper part of the Southerly slope in Hastings Townsite, South Vancouver and Burnaby. It is there that sewerage will first be required. The local planning cannot be done until the general method of dealing with the entire valley has been worked out.

The natural ravines and small water courses will have to be utilized for a long time to take care of the surface water. This will involve the acquisition by the Board of the ownership or control of certain lands, easements, etc., which the detailed plan will show to be necessary. With relatively small expense, such natural drainage channels can have their capacity greatly increased. It will be evident that this land can be acquired at the present time at a comparatively low cost. Incidentally, it may be suggested that if the trees are retained, a little further expense, in the way of bridle paths, etc., will convert these ravines into attractive park areas, which will add to the value of the adjacent districts.

The above remarks are more or less applicable to the method of treatment and use of the gullies around Point Grey, and of those discharging into the North Arm of the Fraser, in Burnaby, South Vancouver and Point Grey. Many of these will not be required for some

time, but the control of the necessary land should be acquired, and the indiscriminate removal of the trees prohibited.

Certain applications for drainage have already been made to the Board for some small districts on the Fraser River side of the divide, which indicate the necessity of making a detailed study of the system on that slope as well.

Imperial Street Outfall

Another feature of the main scheme which should receive early consideration is the proposed main outfall at Imperial Street. This is one of the most important parts of the system. It is intended to discharge the domestic sewage of practically the whole area sloping toward English Bay and False Creek, which will be conducted to it by the proposed English Bay interceptor from the East, and by a much smaller one from the high land to the West. The Report located the end of this outfall about a mile off shore in line with Imperial Street. Soundings and borings should be made in order to discover the nature of the material along this line and other information required to determine its final position.

False Creek—English Bay Interceptor.

The English Bay interceptor is the largest and most costly single piece of work in the entire scheme, but the manner in which its design and that of the whole system of sewers on the English Bay—False Creek slope are interrelated determines the effectiveness with which the shore waters will be protected from pollution by domestic sewage. The greater the proportion of the total area built on the combined system, the greater the quantity of domestic sewage which will overflow during heavy rains.

The Report contemplated the adoption of the separate system on practically all of the Bridge Street and Balaclava areas then unsewered, and the interceptor was figured on that basis. When the Tenth Street branch of the Balaclava Sewer was undertaken in 1914, I understand that a change was made by the board in the system of sewering this area, from separate to combined. I am not sure whether this change was intended to be restricted to the area served by this sewer, or to apply to the whole English Bay—False Creek slope. A change of this kind involves changes in the design of the interceptor, in the connecting structures, and probably in the capacity of the outfall. It also, as I have said, increases the extent of the foreshore pollution during rains. For some years, while the

population is small, this may not make much difference, but we are building for a long future, when the population on the area will be much greater, and presumably aesthetic standards more exacting. The Report referred to such matters in this way:—

> "It must not be forgotten, however, that the luxury of to-day becomes the necessity of tomorrow, and in considering a scheme of this magnitude, the trend of modern practice must be taken into account, rather than the actual methods in use at the present time."

A final decision as to the question of eliminating the separate system on this slope should be deferred until the detailed study and plan are completed.

In any event, there is no immediate need for either outfall or interceptor. As a matter of fact, if the ultimate conditions which would result from the adoption of the combined system over the entire slope were to be taken as any criterion of the public requirements in that respect, they would not be needed, in all probability, for some years to come. It is possible, however, that after the comprehensive detailed plan is completed, it may be found expedient to construct a limited section of the interceptor and a portion of the outfall. Meanwhile, the present temporary arrangements, if looked after, will be amply sufficient to prevent anything in the way of a real nuisance.

Tenth Avenue Branch Extension.

The original design of the Maple Street trunk sewer of the City of Vancouver provided only for the tributary drainage area within the city limits. This design was later modified to include the portion lying to the South, within the Municipality of Point Grey. This modification anticipated diverting part of the drainage at Tenth Avenue and Cedar Street, to the future trunk sewer of the Balaclava area.

An agreement has been made with the City that the Board "request the Lieutenant-Governor in Council for permission to construct a continuation of the Tenth Avenue branch, Balaclava area, from Vine to Cedar."

This proposition is in general accordance with the joint scheme and should, in my opinion, be carried into effect. I am not aware, however, that the matter is at all urgent. The conditions cannot be very different from what they have been for the last three or four years, and unless the Maple Street sewer is already overcharged, I do not think this work should be gone on with at present.

Transfer of Sewers.

Reference has been made to certain sewers in the Bridge Street area which the Board has agreed to ask permission from the Lieutenant-Governor in Council to take over from the City and include within the joint scheme—the price agreed upon is $93,678.12. I see no reason why this transfer should not be completed and the money paid to the City as soon as the suggested arrangements can be made.

The final adjustment of the matter of taking over the Kaye Road trunk sewer built by the Municipality of Point Grey, has, I understand, been referred to Mr. Creer and Mr. N. J. Ker.

There are certain other matters which may appropriately engage the attention of the Board and which might be included in the studies made in connection with the detailed plan. I merely mention them, without recommendation, as follows:—

(a) Methods of utilizing the interceptors of the joint scheme in providing for the sewerage of reclaimed lands at the upper end of False Creek, and of the low-lying lands adjacent thereto.

(b) The possible necessity of diverting the sewage now discharging at the Commercial Drive outfall, to Clark Drive.

(c) The unsatisfactory condition of affairs in connection with the City Sewer discharging near Evans, Coleman & Evans wharf.

Future Loans.

Up to December 31st, 1916, the total Expenditure of the board amounted to $1,861,897.10, made up as follows:—

Administration	$70,869.53	
Engineering	40,804.06	
Preliminary Expenses	41,847.44	
General Investigations	9,541.25	
Plant, Stores and Revenue Account	5,642.07	
		$168,704.35
Sewers purchased—		
City	303,260.47	
Point Grey	40,000.00	
		343.260.47
Works constructed		$1,349,932.28
Total		$1,861,897.10

Against this is to be credited a certain sum for plant, stores, etc., etc.

The balance on hand at the end of the year was therefore something less than $400,000. This will be sufficient to complete the West End Intercceptor, and carry out the recommendations of this report, and still leave a considerable margin. A loan will, however, be required to pay the City of Vancouver for the balance of the Bridge Street area trunk sewers, as soon as permission for the transfer has been obtained from the Lieutenant-Governor in Council.

Conclusion.

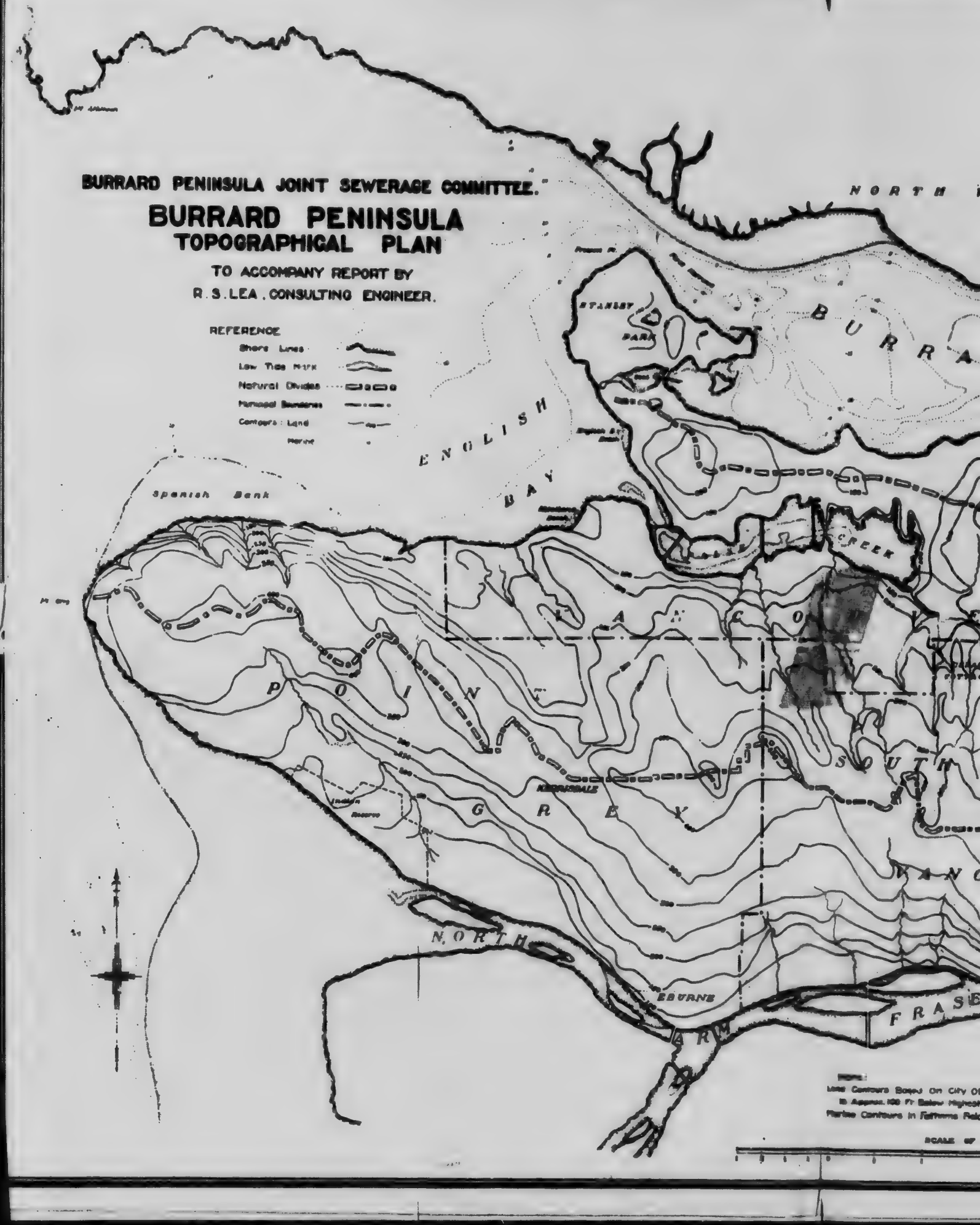
Finally, an illustrated report, covering the four years' operations of the Board should be prepared on the lines of the annual reports usually issued in connection with other projects of the magnitude and importance of this one. It would describe the work which has so far been carried out, with methods and details of construction. It would include the general layout as shown by the completed detailed plan, with illustrations and drawings of the principal structures. Many of these are of unusual interest, such as the various sections of tunnel work; the outfall at Clark Drive which discharges sewage at the bottom of Burrard Inlet through 1600 feet of tunnel; the China Creek sewer, which in March of last year carried for several hours a flow of water equal to the low water discharge of the Bow River at Calgary, and that without taxing it to half its capacity; and many other works built and proposed.

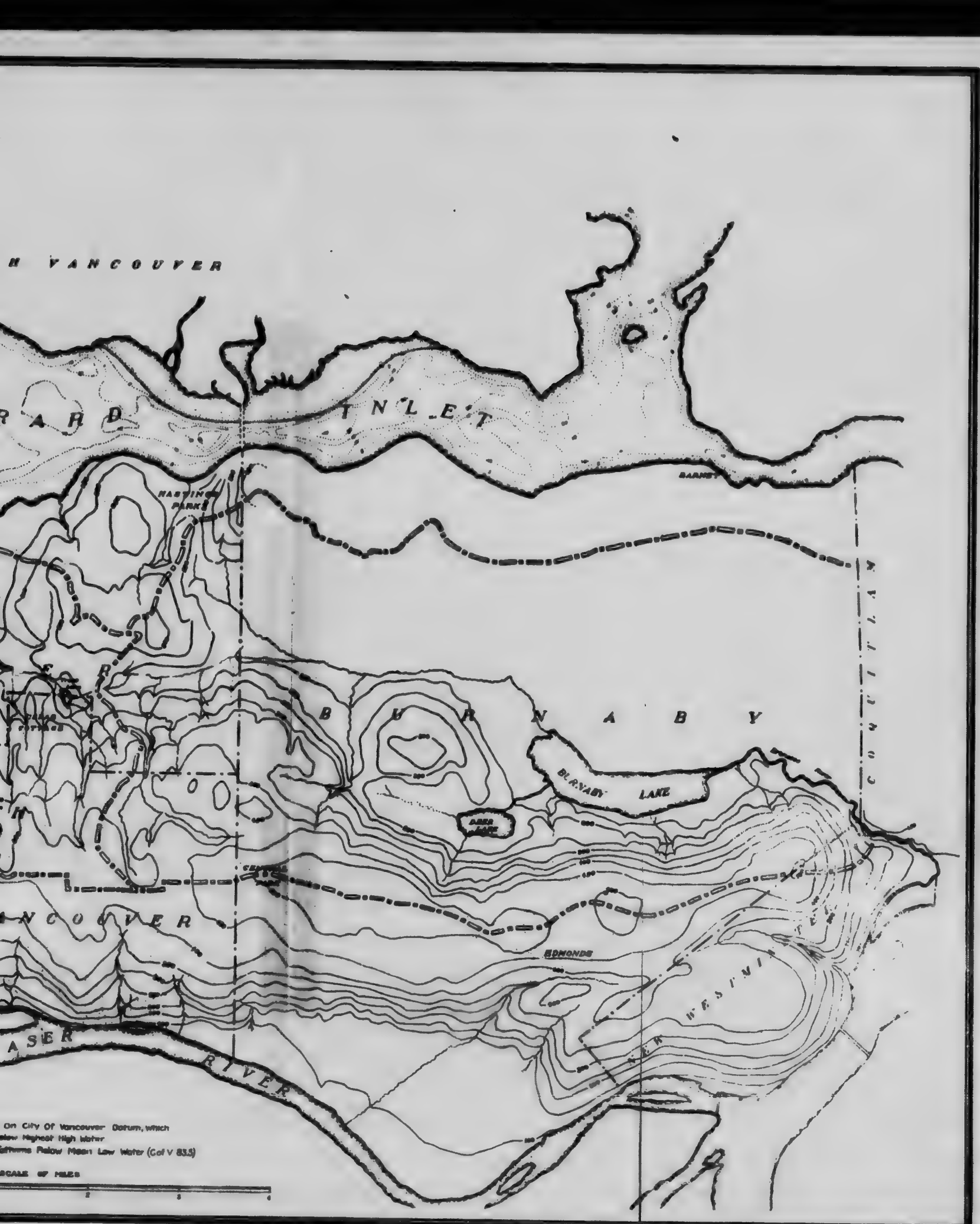
This report should be published as soon as possible after the detailed plan is completed. **It would pay.** The information which it would present would be a source of pride and interest to the citizens of the District, and would be of benefit to other municipalities confronted with similar problems. It would place on record the wisdom and enterprise of those who initiated the project and supported it until its success was assured. It would also advertise the fact that Vancouver, Point Grey, South Vancouver and Burnaby had the courage and foresight to undertake a sewerage and drainage project of such magnitude, and to deal with it in a large way, commensurate with the opportunities afforded by their unexcelled natural advantages.

In conclusion, I wish to repeat that the suggestions and recommendations which I have made in regard to the future operations of the Board, have been made principally for the purpose of indicating and emphasizing the necessity of carrying out the work as nearly as possible in accordance with a thoroughly co-ordinated and comprehensive plan, prepared in advance, and based upon uniform principles of design. Each part of the work as constructed will then perform its function without conflicting, and in complete harmony with all the others. In this way only can the decision to embark on such an undertaking be entirely justified, and the objects aimed at in the scheme as originally presented be fully attained.

Respectfully submitted,

(Signed) R. S. LEA.


BURRARD PENINSULA JOINT SEWERAGE COMMITTEE.
BURRARD PENINSULA
TOPOGRAPHICAL PLAN
TO ACCOMPANY REPORT BY
R. S. LEA, CONSULTING ENGINEER.
REFERENCE
Shore Lines
Low Tide Mark
Natural Divides
Municipal Boundaries
Contours: Land
Marine
ENGLISH BAY
Spanish Bank
STANLEY PARK
BURRARD
KITSILANO
POINT GREY
NORTH ARM
EBURNE
FRASER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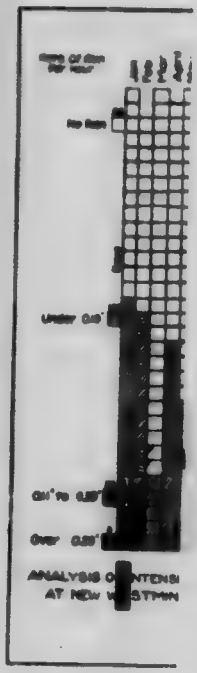

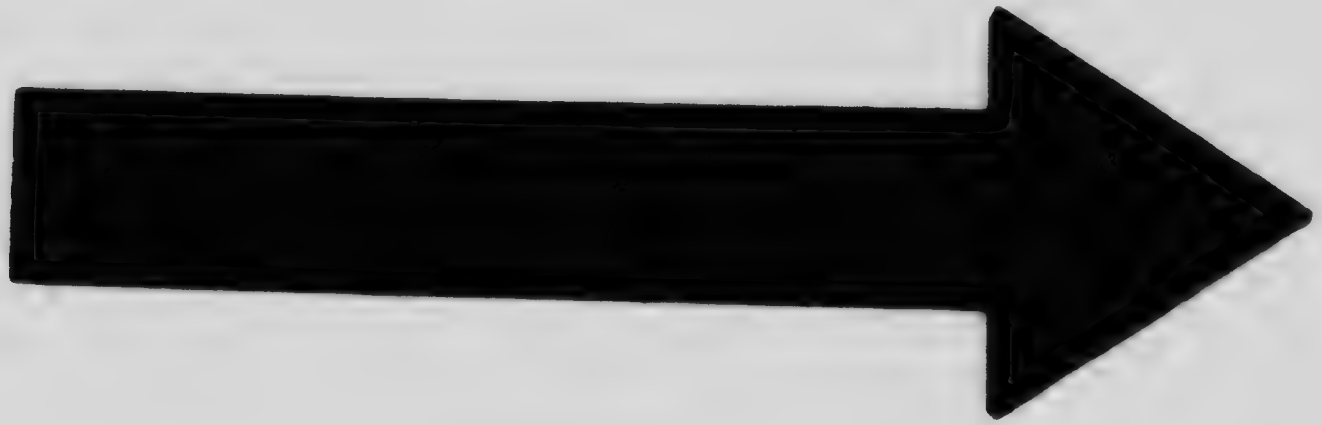

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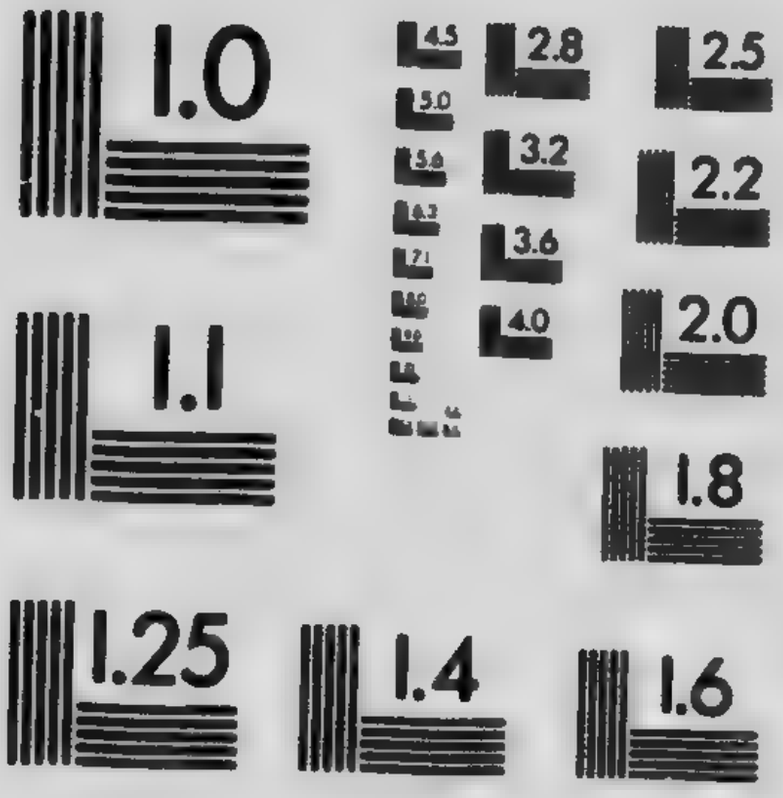

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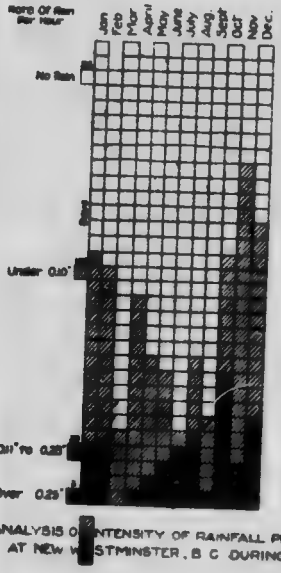

ANALYSIS O[illegible]NTENSITY OF RAINFALL PER HOUR
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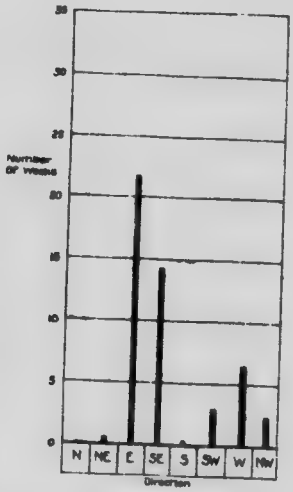
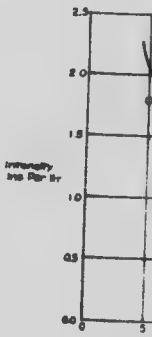
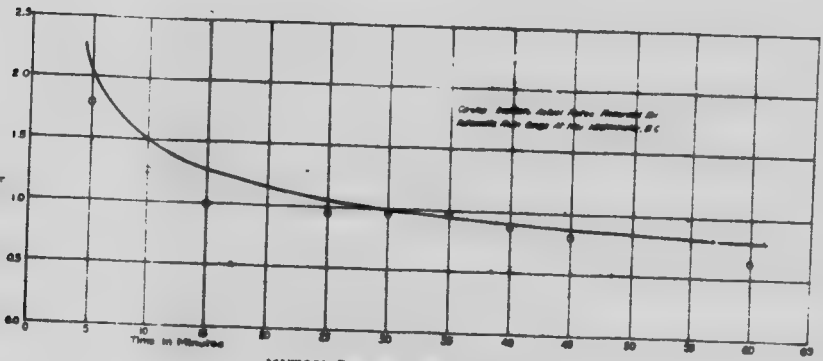


PREVAILING WINDS





MAXIMUM RAINFALL INTENSITY CURVE

METEOROLOGICAL CHART.

TO ACCOMPANY REPORT BY
R.S.LEA, CONSULTING ENGINEER

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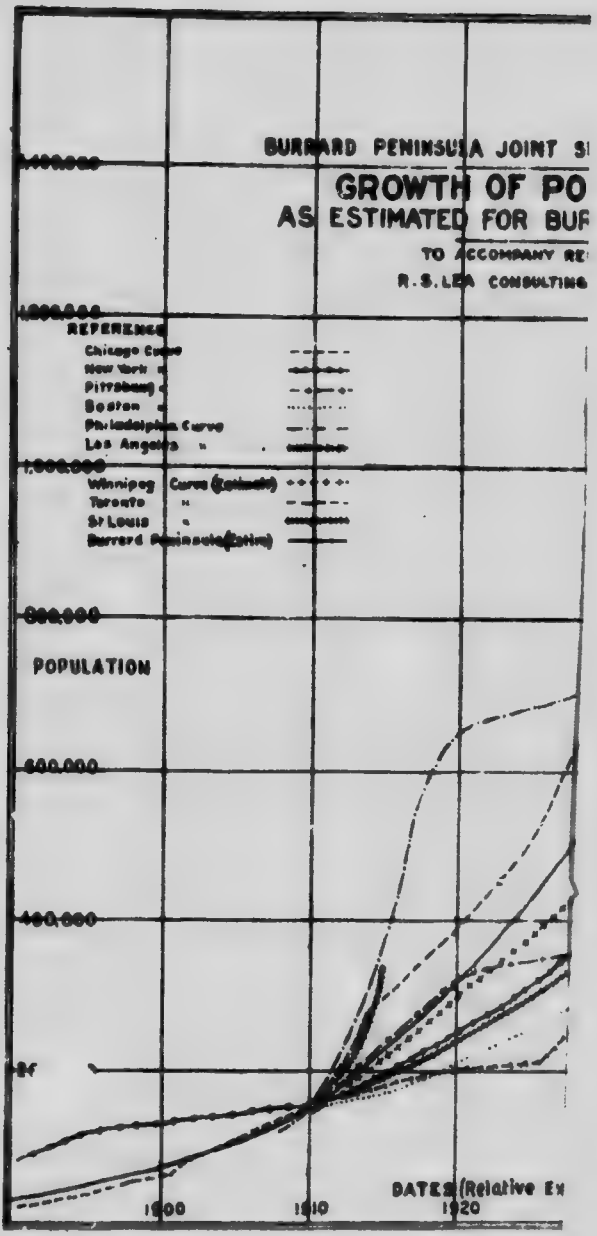
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R. S. LEA CONSULTING
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Toronto "
St Louis "
Burrard Peninsula (Estimate)
POPULATION
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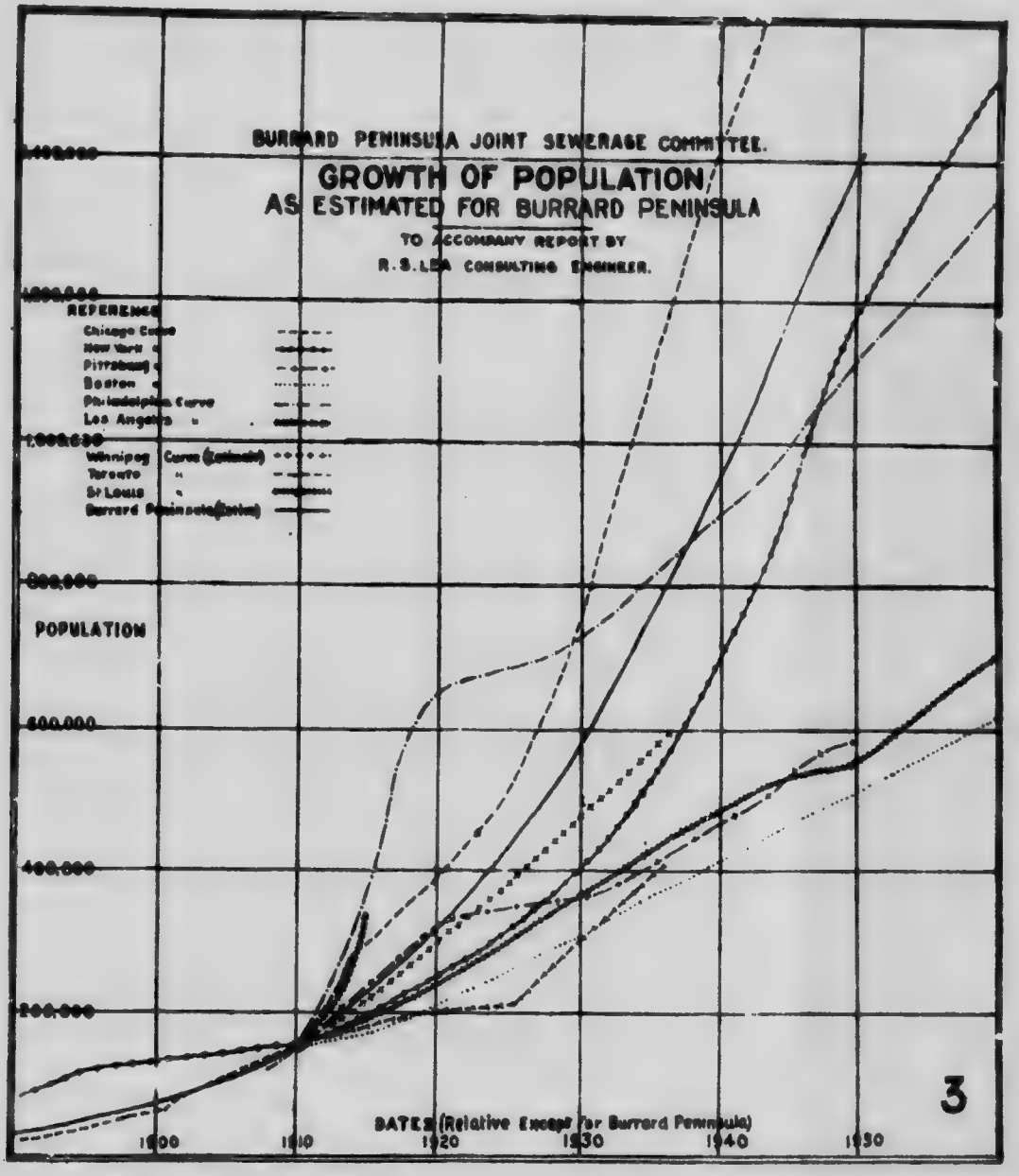
BURRARD PENINSULA JOINT SEWERAGE COMMITTEE.
GROWTH OF POPULATION,
AS ESTIMATED FOR BURRARD PENINSULA
TO ACCOMPANY REPORT BY
R. S. LEA CONSULTING ENGINEER.
REFERENCE
Chicago Curve
New York "
Pittsburg "
Boston "
Philadelphia Curve
Los Angeles "
Winnipeg Curve (Estimate)
Toronto "
St Louis "
Burrard Peninsula (Estimate)
POPULATION
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DATES (Relative Except for Burrard Peninsula)
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1920
1930
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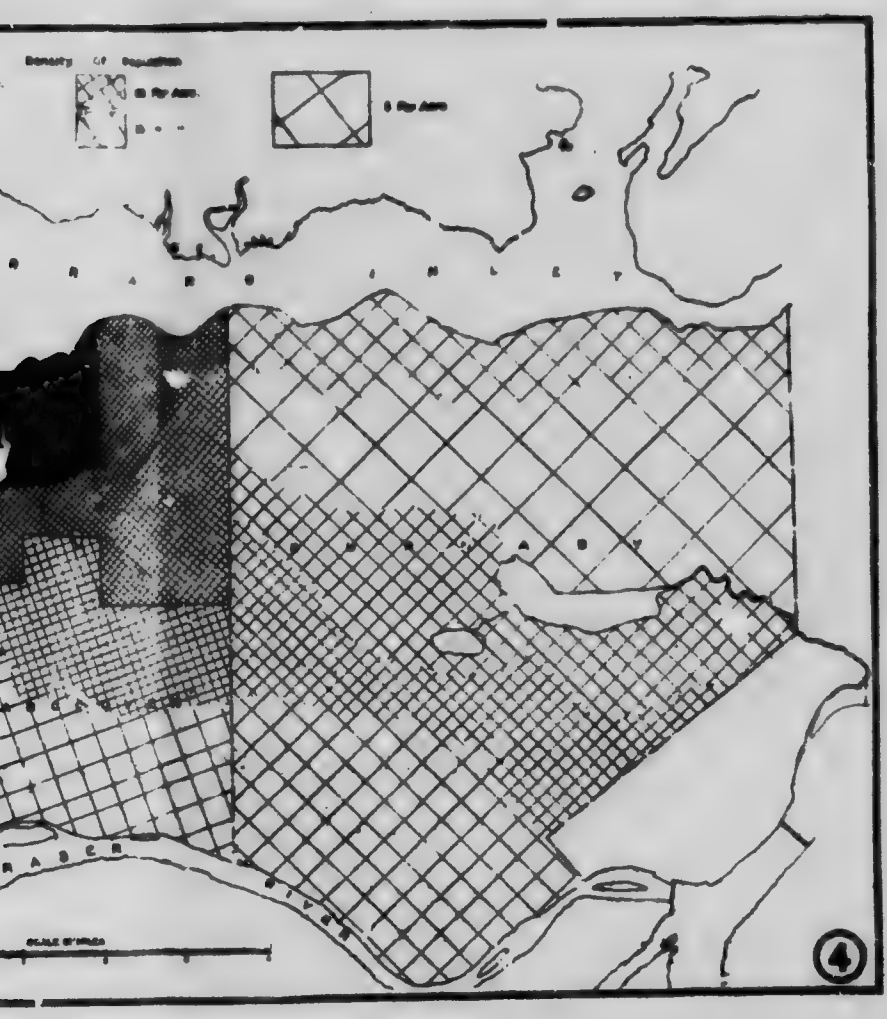
1950
3


PLAN OF BURRARD PENINSULA
DISTRIBUTION OF POPULATION ESTIMATED FOR 1990.
REFERENCE.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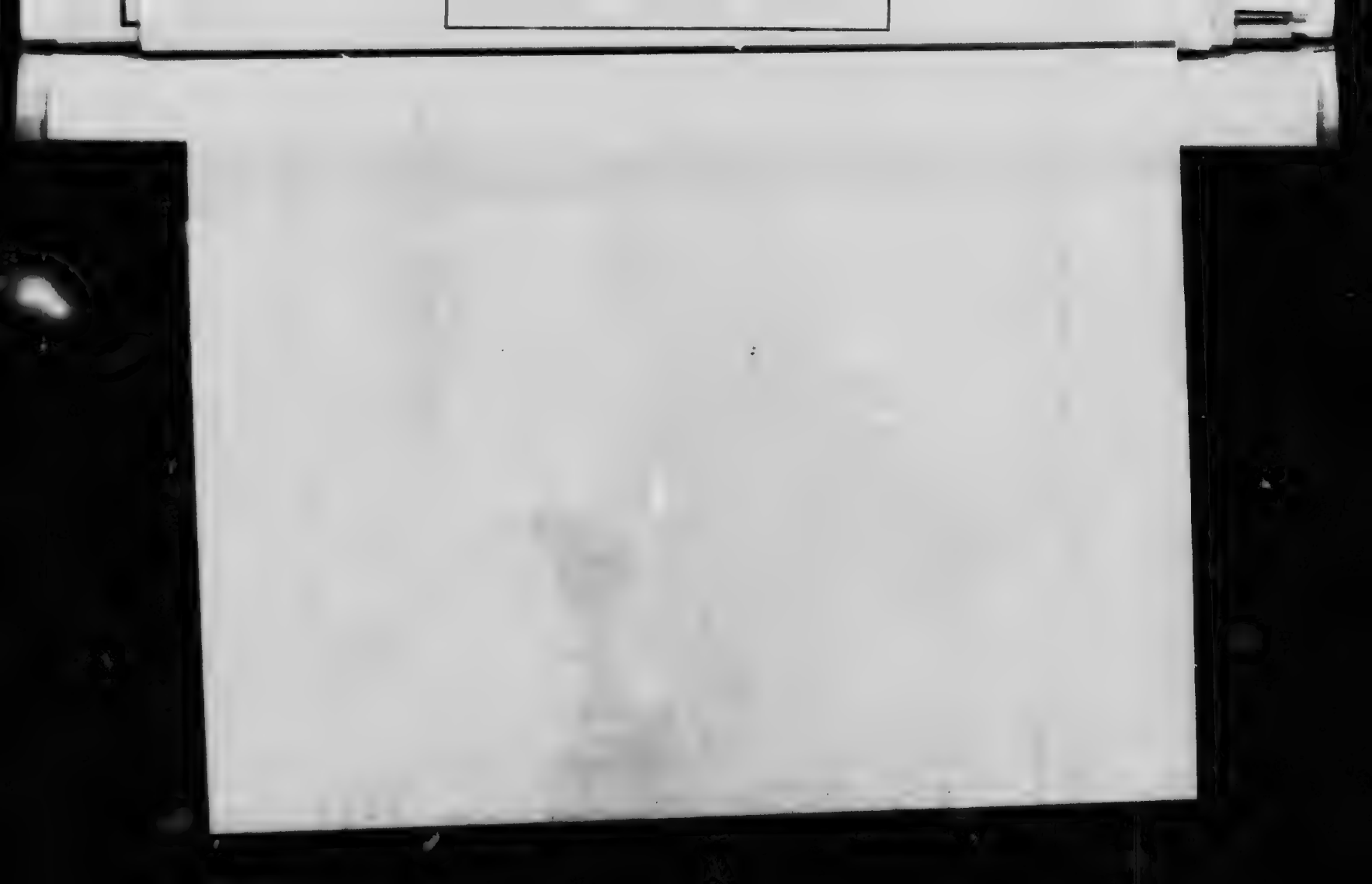
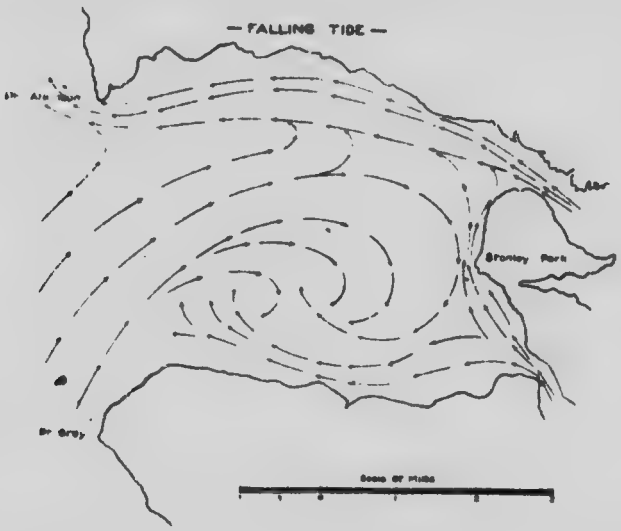
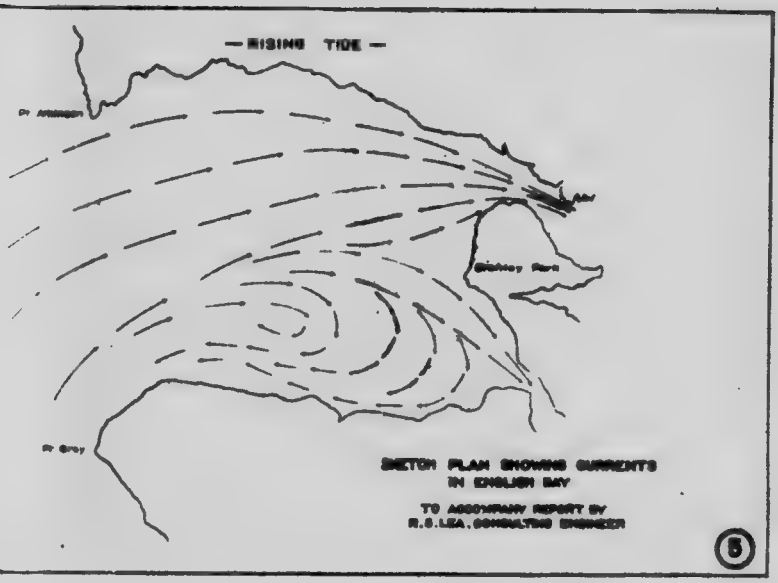


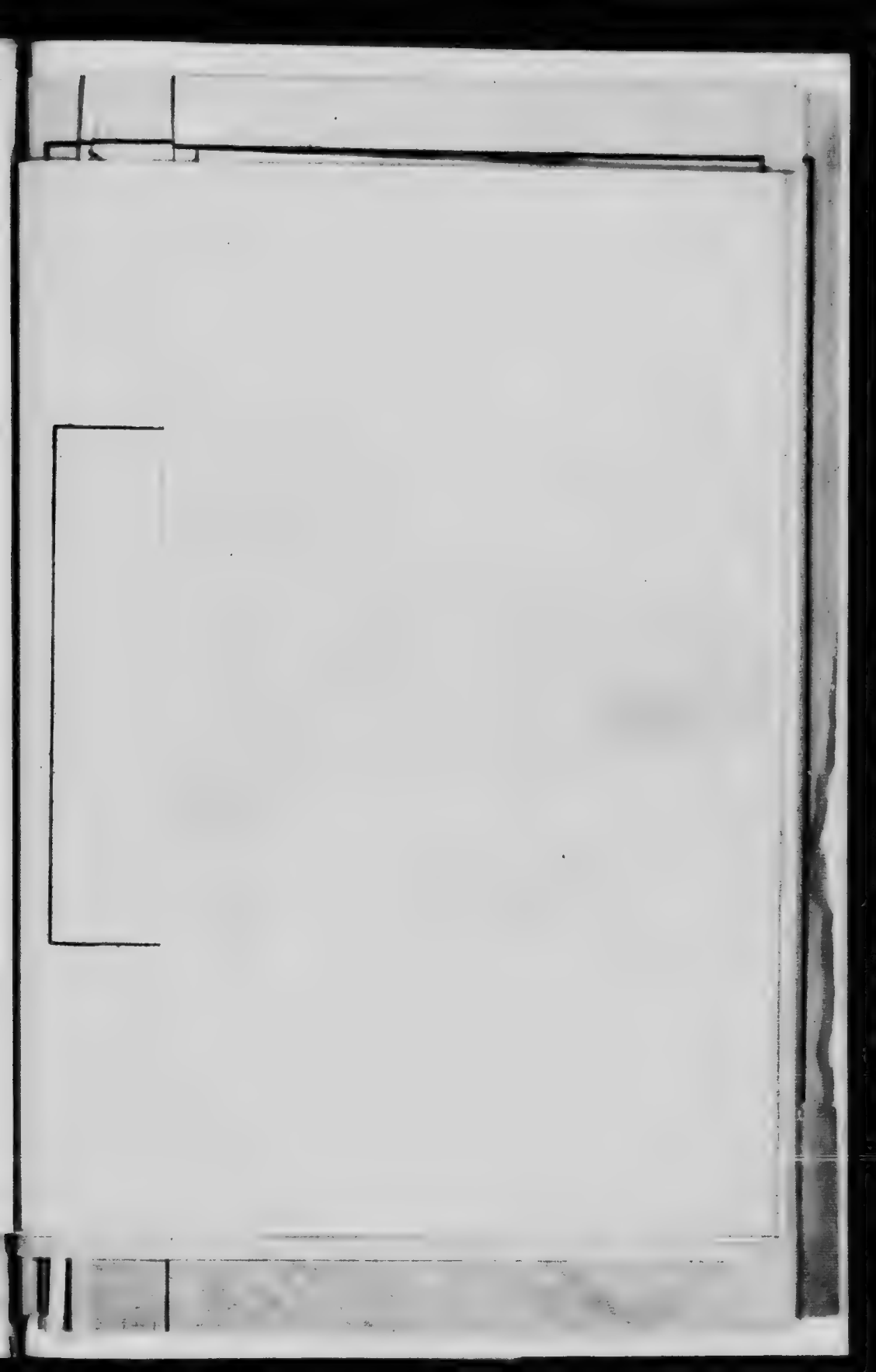

— FALLING TIDE —
Bromley Park



SKETCH PLAN SHOWING CURRENTS
IN ENGLISH BAY

TO ACCOMPANY REPORT BY
R.S.LEA, CONSULTING ENGINEER

5

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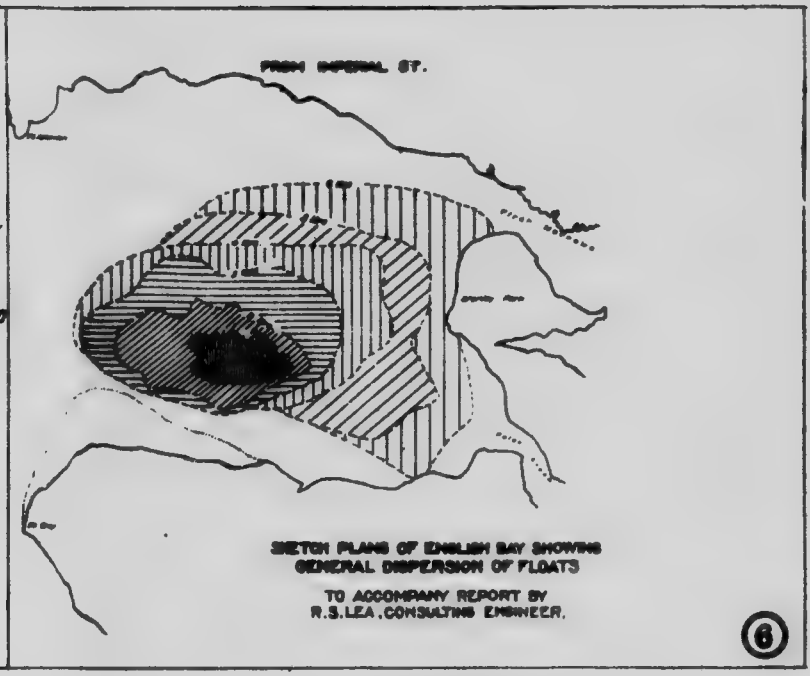
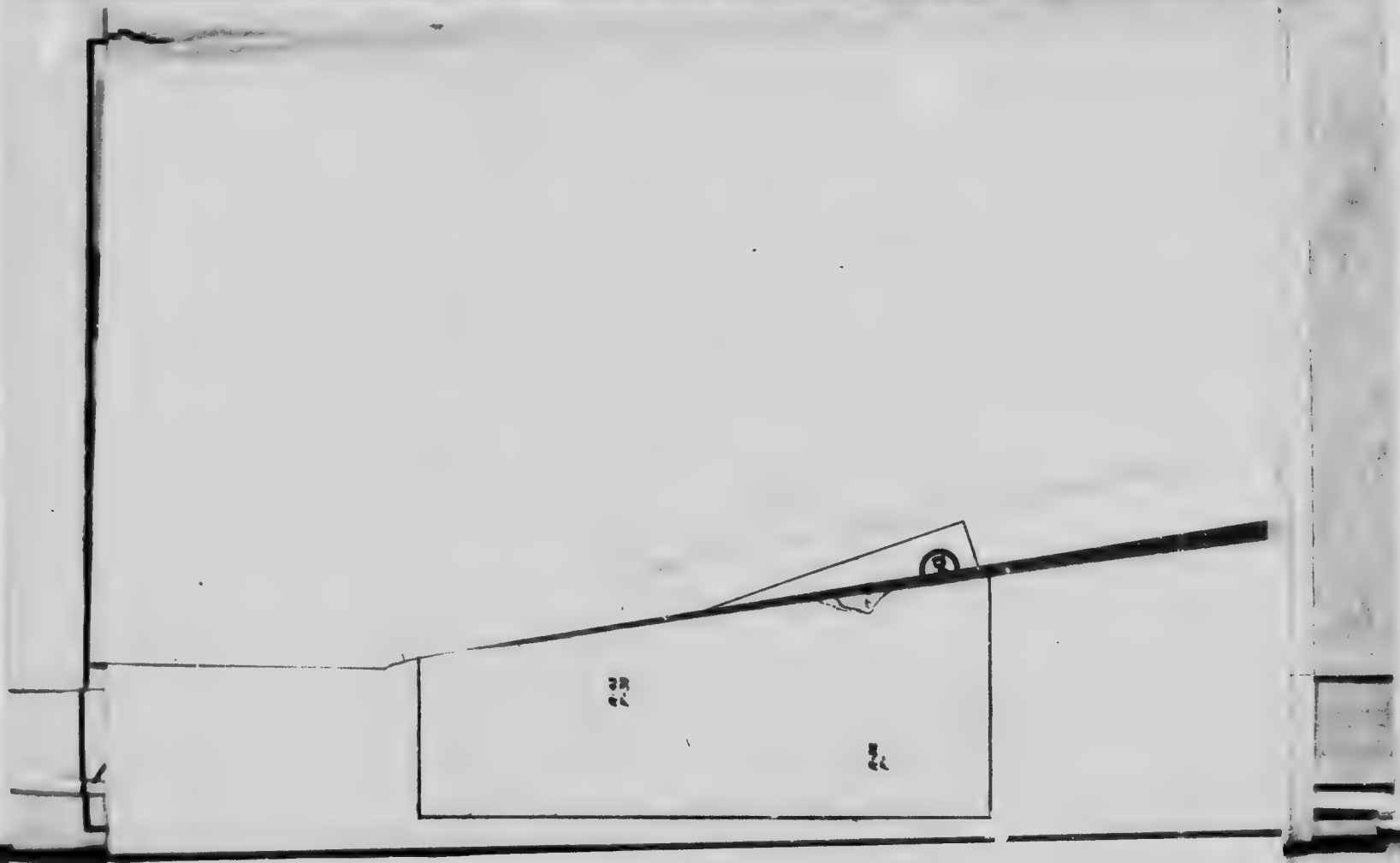
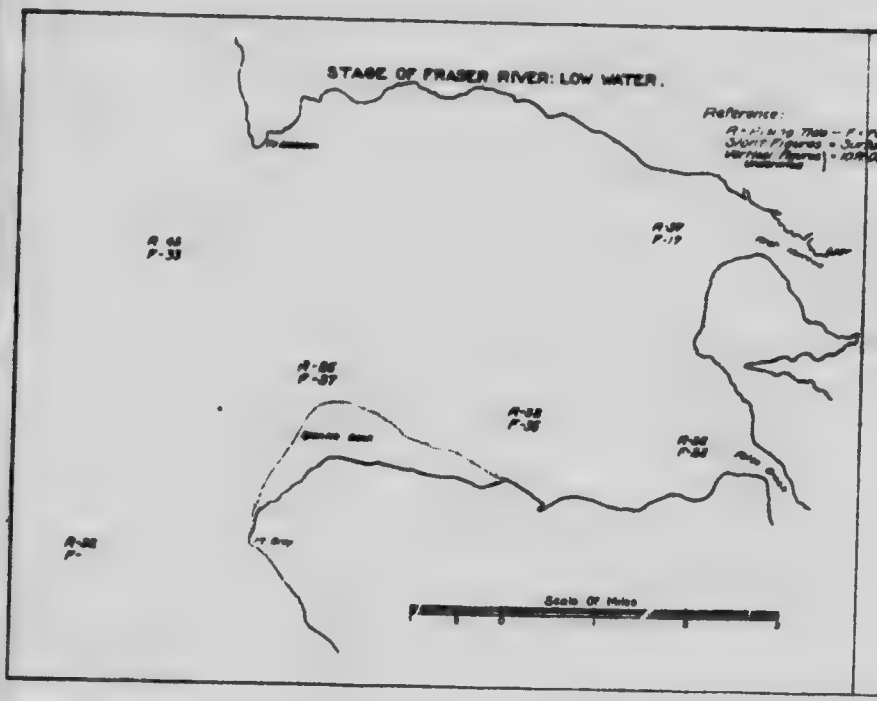


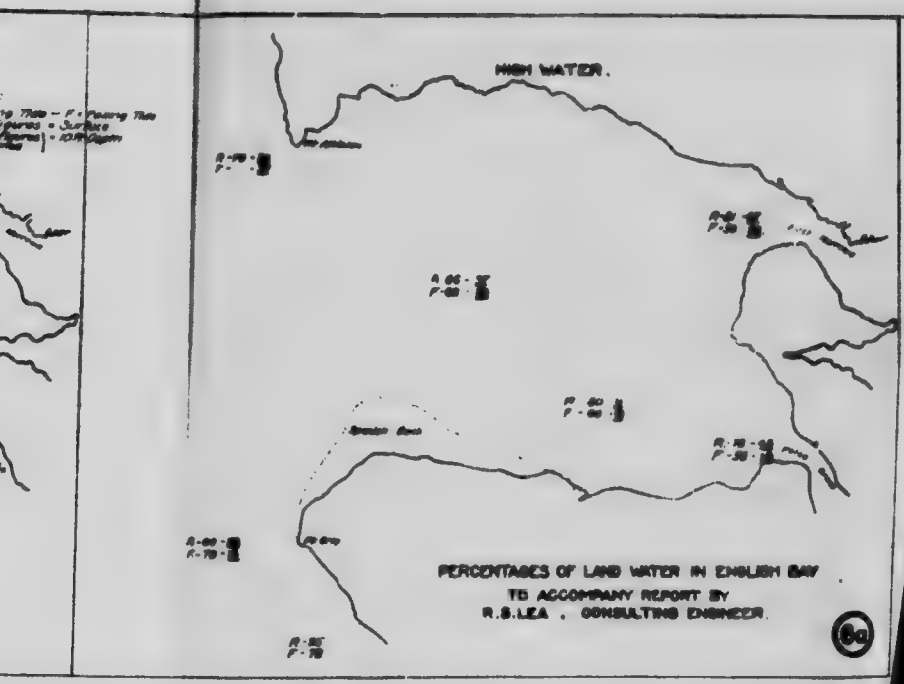
SKETCH PLANS OF ENGLISH BAY SHOWING
GENERAL DISPERSION OF FLOATS

TO ACCOMPANY REPORT BY
R.S.LEA, CONSULTING ENGINEER.

6




STAGE OF FRASER RIVER: LOW WATER.
Reference:
Scale Of Miles


HIGH WATER.
PERCENTAGES OF LAND WATER IN ENGLISH BAY
TO ACCOMPANY REPORT BY
R.S.LEA . CONSULTING ENGINEER.
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Spanish Park
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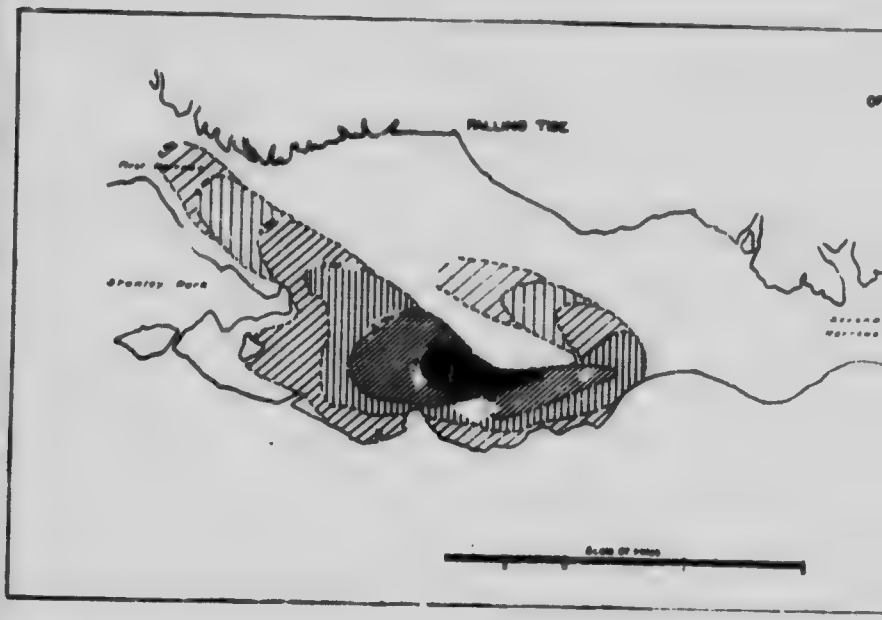
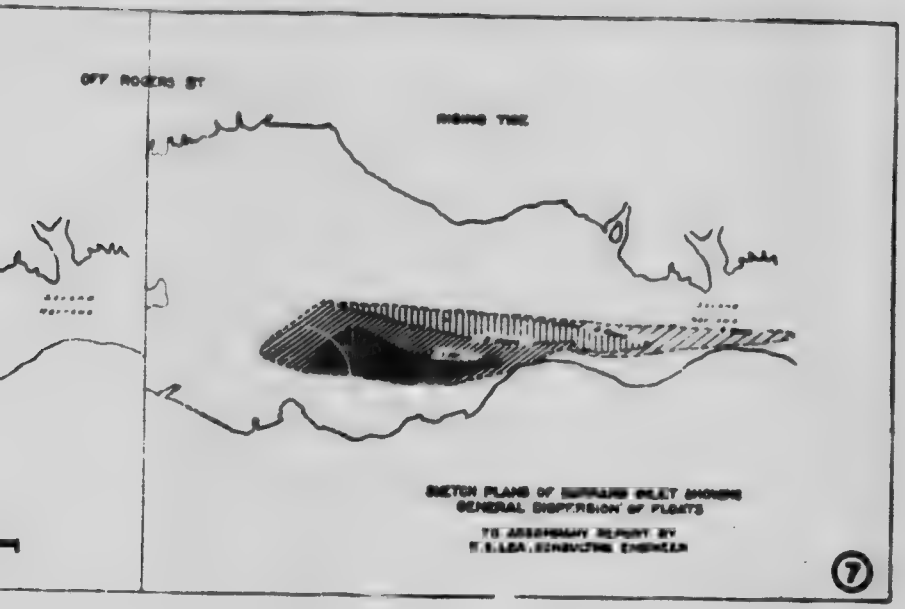

FALLING TIDE



SKETCH PLANS OF [illegible] INLET SHOWING
GENERAL DISPERSION OF FLOATS

TO ACCOMPANY REPORT BY
T. E. LEA, CONSULTING ENGINEER

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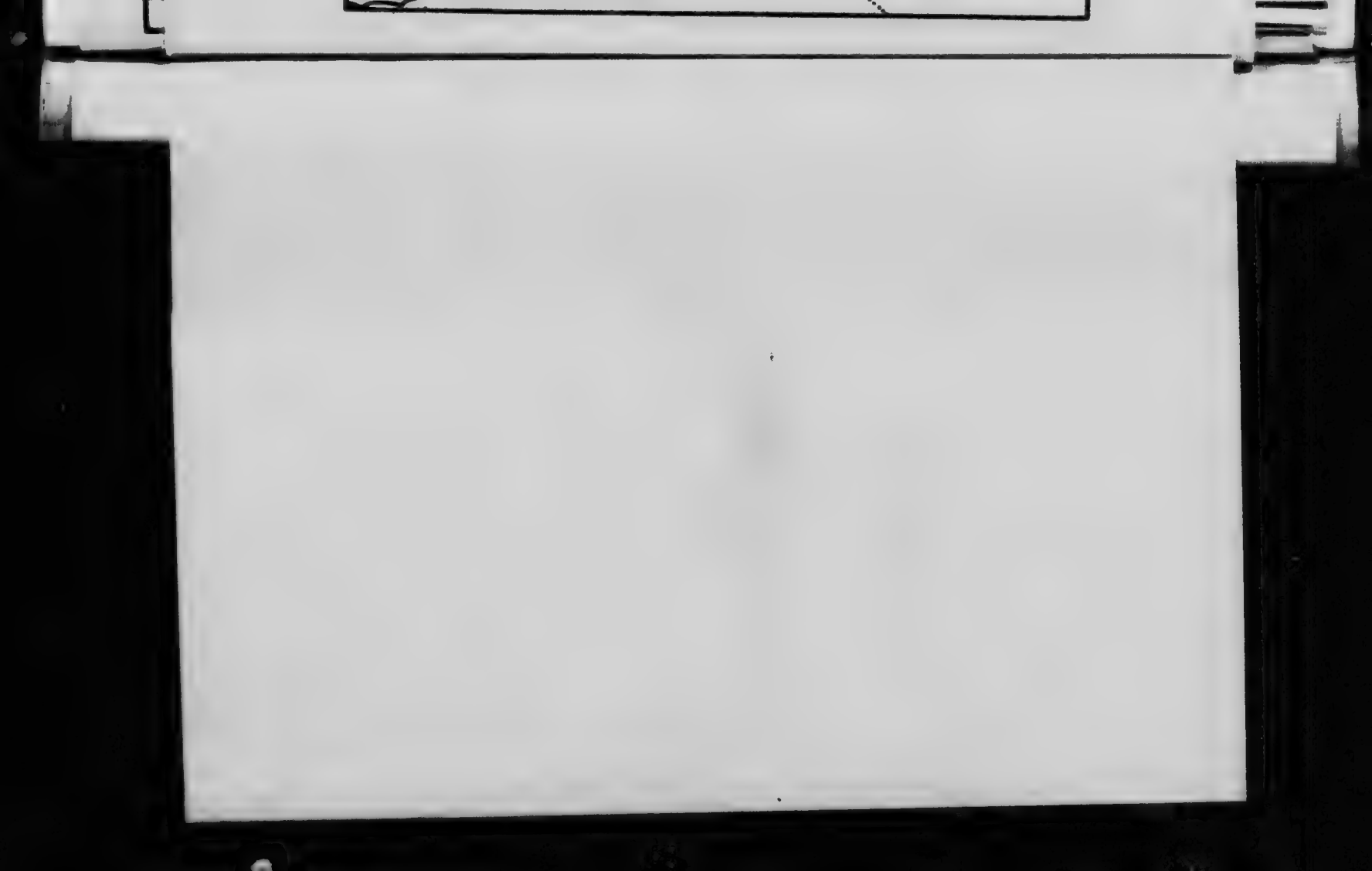
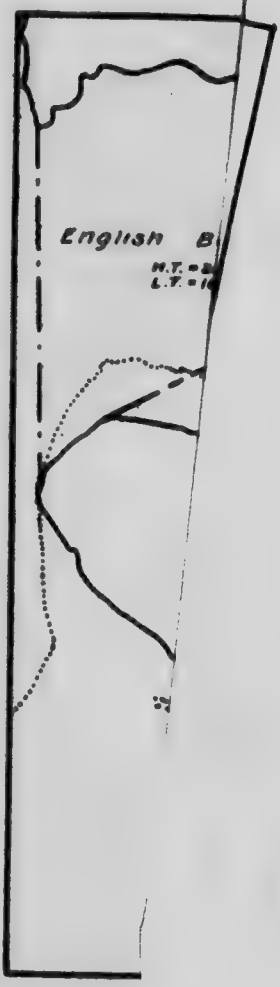
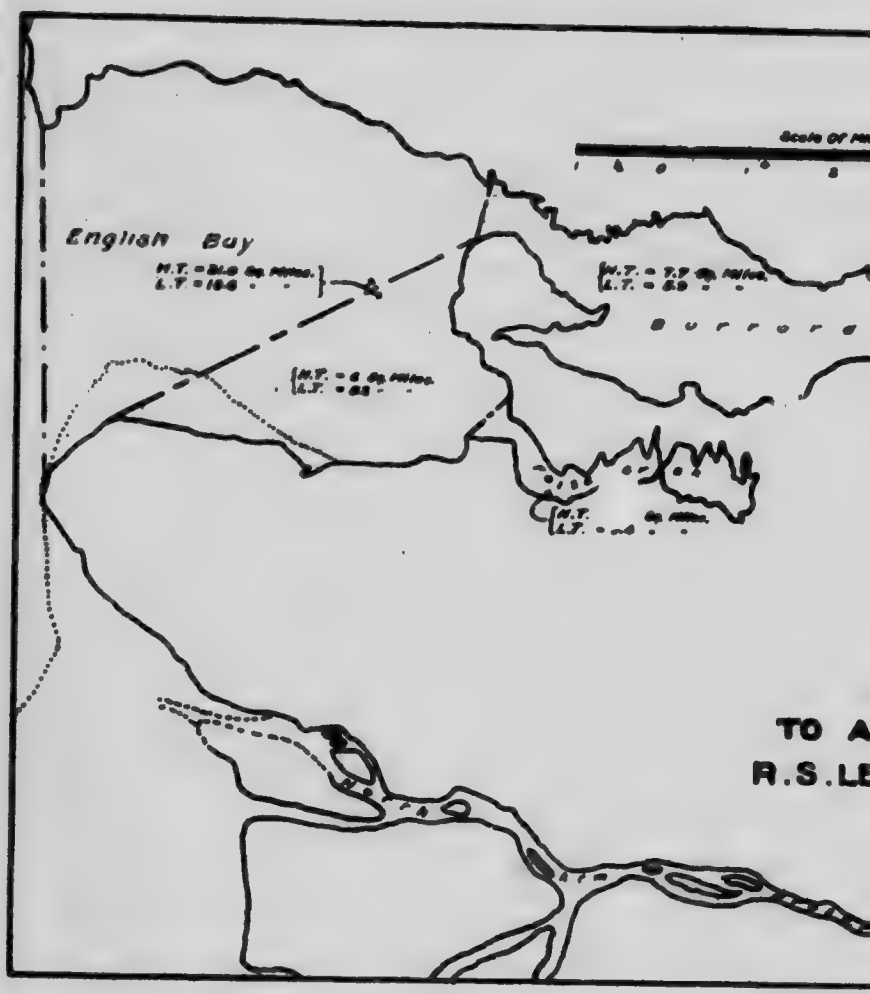
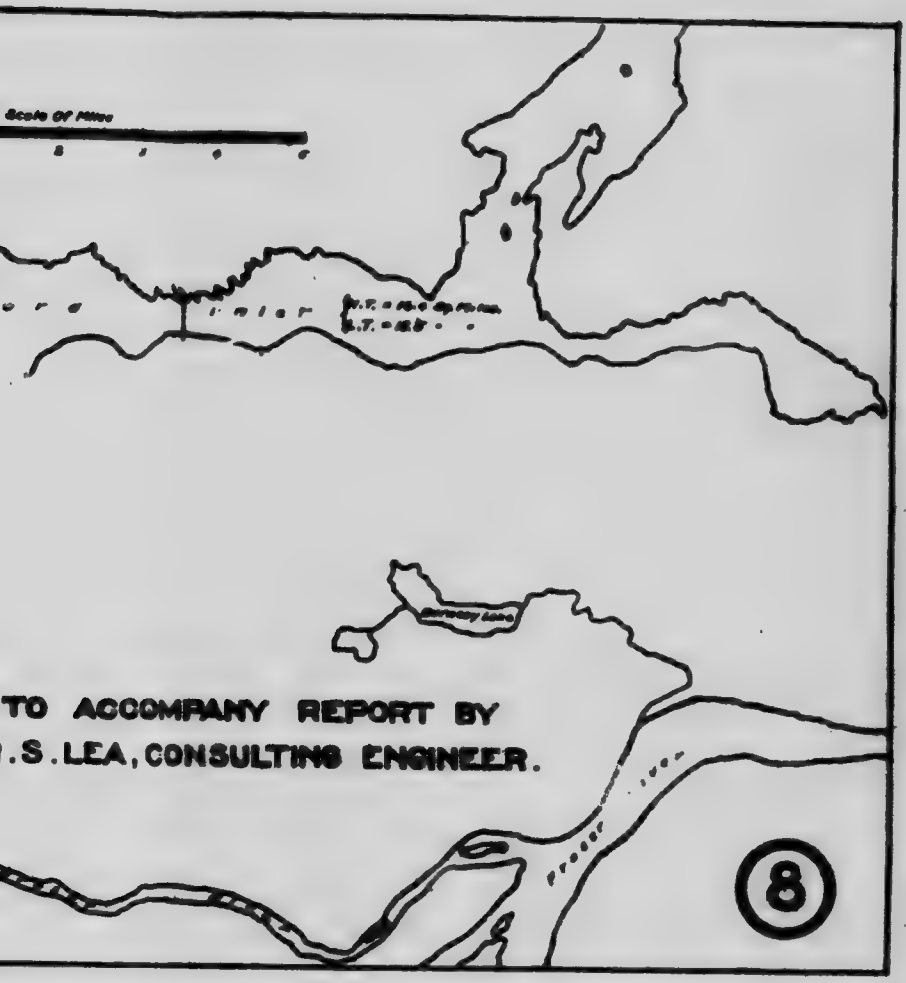



English B


English Bay
TO A
R.S.LE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8


SPARROW BANK
P O I N T
G R E Y
S T U R G E O N
B A N K


BURNABY
VANCOUVER
BURRARD PENINSULA JOINT SEWERAGE COMMITTEE.
BURRARD PENINSULA & SURROUNDING WATERS
HYDROGRAPHIC PLAN
TO ACCOMPANY REPORT BY
R. S. LEA, CONSULTING ENGINEER.

U
R

BURRARD PENINSULA JOINT SEWERAGE COMMITTEE

PLAN OF BURRARD PENINSULA

DRAINAGE AREAS OUTFALLS & TRUNK SEWERS

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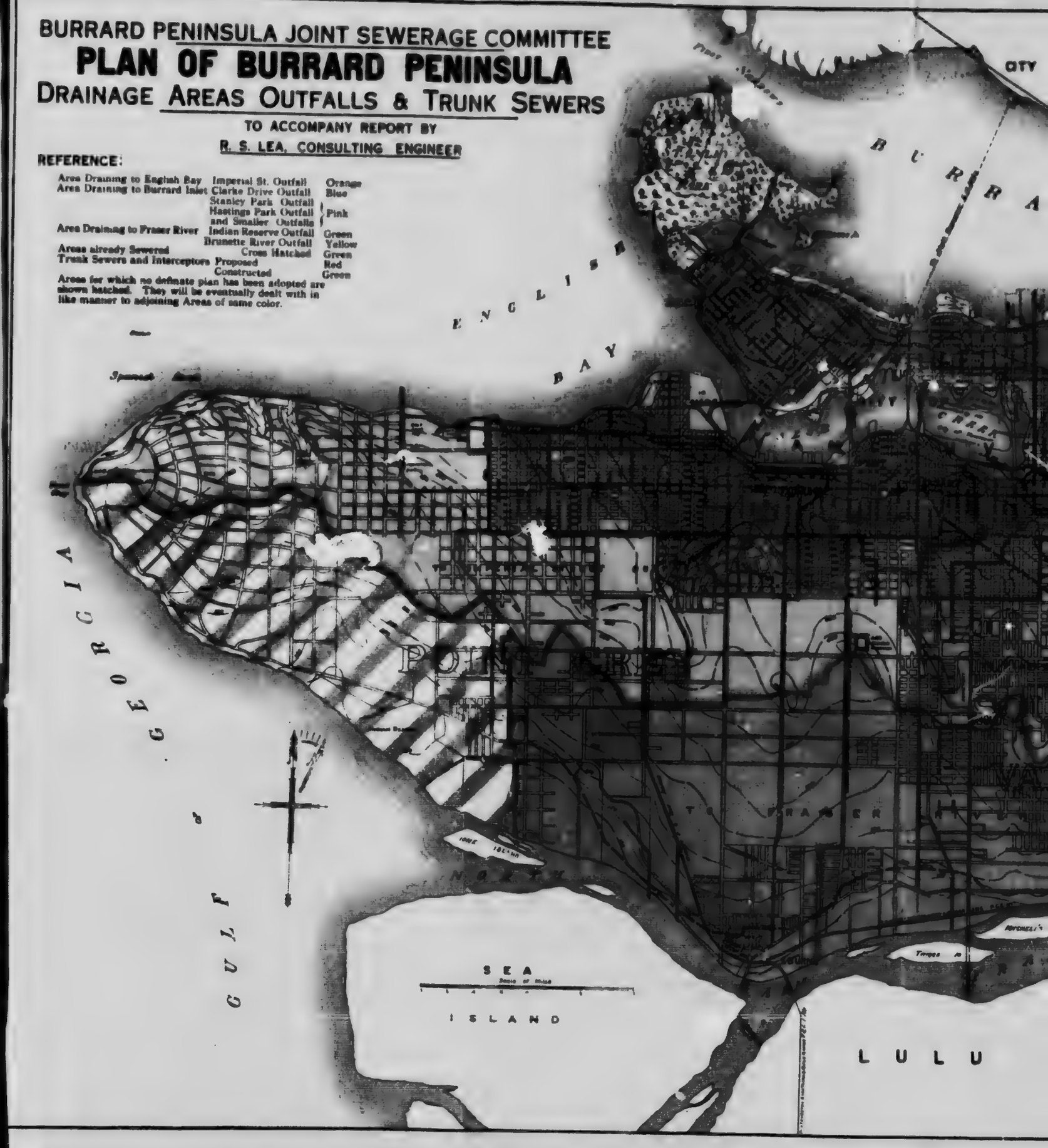
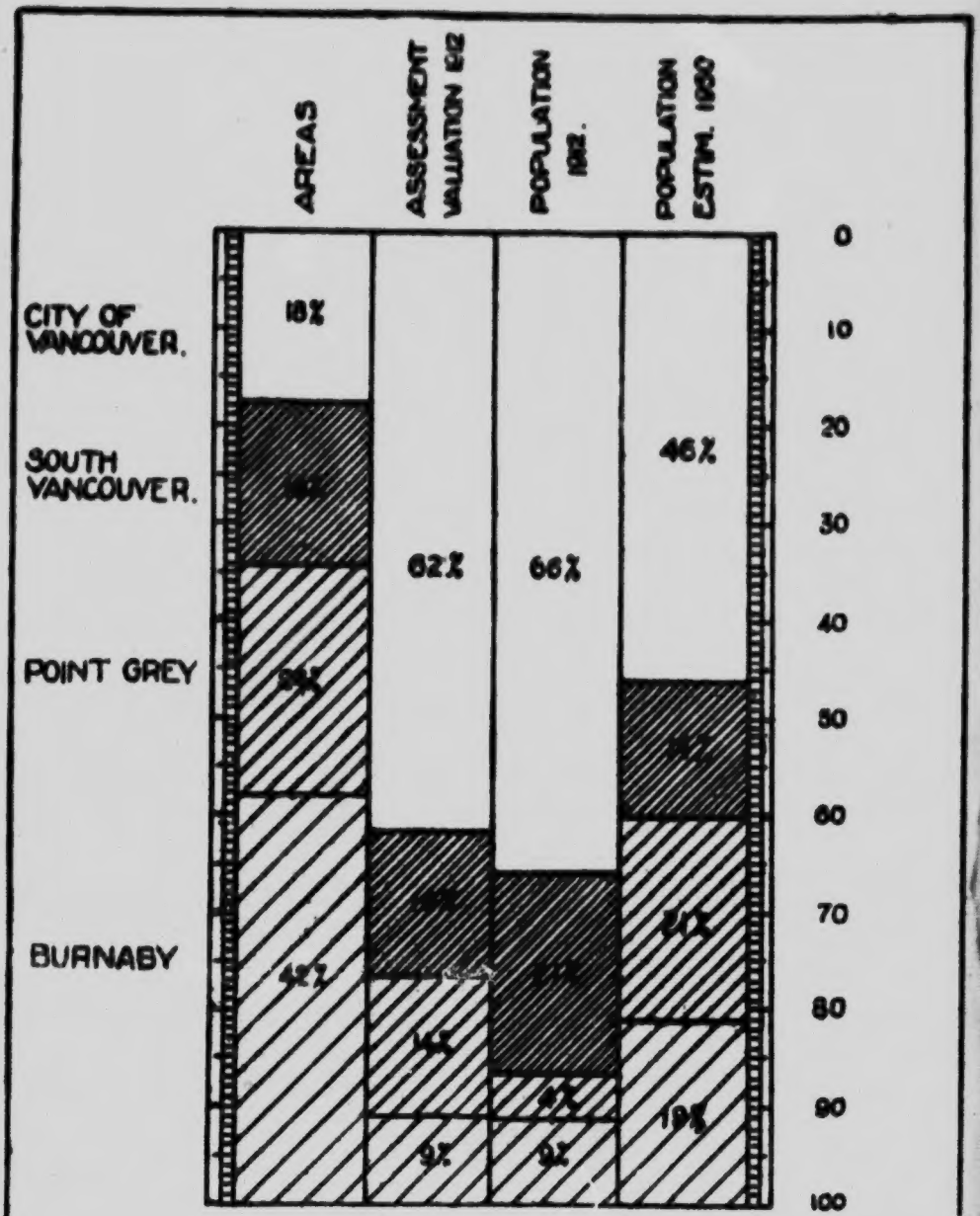
REFERENCE:

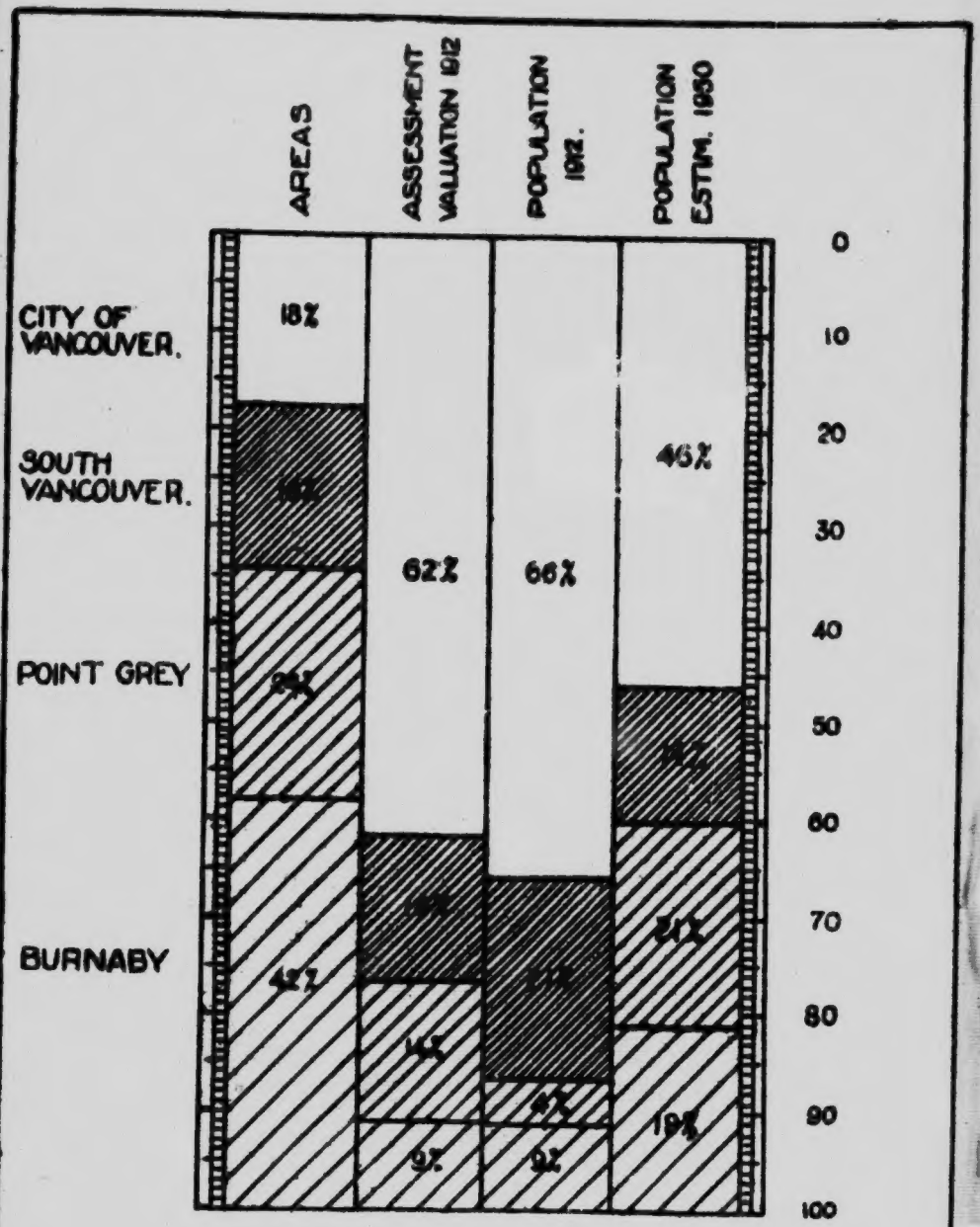
Area Draining to English Bay	Imperial St. Outfall	Orange
Area Draining to Burrard Inlet	Clarke Drive Outfall	Blue
	Stanley Park Outfall	
	Hastings Park Outfall	Pink
	and Smaller Outfalls	
Area Draining to Fraser River	Indian Reserve Outfall	Green
	Brunette River Outfall	Yellow
Areas already Sewered	Cross Hatched	Green
Trunk Sewers and Interceptors	Proposed	Red
	Constructed	Green

Areas for which no definate plan has been adopted are shown hatched. They will be eventually dealt with in like manner to adjoining Areas of same color.




CITY OF NORTH VANCOUVER
INLET
BURNABY
SURREY
ISLAND


AREAS
ASSESSMENT VALUATION 1912
POPULATION 1912.
POPULATION ESTIM. 1950
CITY OF VANCOUVER.
SOUTH VANCOUVER.
POINT GREY
BURNABY
18%
62%
66%
46%
42%
14%
9%
4%
9%
19%
0
10
20
30
40
50
60
70
80
90
100



AREA, ASSESSMENT & POPULATION CHART

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(11)